INTERSTATE HIGHWAY 90 RECONNAISSANCE STUDY BEARMOUTH EAST AND WEST MONTANA

A REPORT TO

THE MONTANA HIGHWAY COMMISSION

December, 1962

INTERSTATE HIGHWAY 90

RECONNAISSANCE STUDY

BEARMOUTH EAST AND WEST

MONTANA

A Report To

The Montana Highway Commission

By

Meissner Engineers, Inc.

Chicago, Illinois

December, 1962

MEISSNER ENGINEERS INC. · 300 WEST WASHINGTON · CHICAGO 6, ILLINOIS

December 3, 1962

Montana Highway Commission
Helena, Montana

Gentlemen:

We are pleased to submit herewith our engineering report for the Reconnaissance Study of Federal Aid Interstate 90, Bearmouth East and West. This report contains our recommendations concerning the most desirable Interstate route location between Nimrod and Drummond, Montana.

Horizontal alignment investigations for many routes in this area were made utilizing International Business Machine computers and the Digital Terrain Model design system. Written descriptions of the routes investigated accompanied by plans, profiles and cost estimates are included herein.

We would like to take this opportunity to express our appreciation to the members of the Montana Highway Department and the Bureau of Public Roads for their continual cooperation and valuable assistance during all phases of this Reconnaissance Study.

Sincerely yours,

MEISSNER ENGINEERS, INC.

Robert C. Meissner
President

RCM/mm

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INTRODUCTION

This report involves a reconnaissance study for approximately 17 miles of Interstate Highway in Granite County, Montana on Project I-IG-90-3 (4) 132, beginning at a point approximately 1-1/2 miles west of Nimrod and ending at a point approximately 3 miles west of Drummond.

Any route between these points would generally follow the Northern Pacific Railway and Chicago, Milwaukee, St. Paul and Pacific Railroad. The area is mountainous in nature with a flood plain traversing the central portion. Outside of Clark Fork, the area is dissected by two railroads and six utilities.

Detailed topographic maps, at a scale of 1" = 500' and 10 foot contour intervals, were developed for the study. A band width of 2 miles was used with Clark Fork at the center of the mapping.

With the possibility existing of studying many alternate routes a computer design system was utilized to facilitate the analysis of these routes. This system, known as the Digital Terrain Model Design System, is discussed in detail in this report.

In order to arrive at a recommended alignment, the following phases were studied in detail:

1. Geometrics - A complete study of horizontal and vertical alignment for many possible routes was made.

2. Soils and Geology - A geological study was made of the area by use of air photos and field reconnaissance.

3. Hydraulics - A complete study of drainage areas, runoffs, and stream relocations was made to determine the sizes of drainage structures required.

4. Bridges - Recommendations are made for type, length and location of required bridges and major drainage structures.

5. Interchanges - Recommendations are made for interchange types.

6. Relocations - Recommendations for frontage roads to serve abutting property owners are made in this report.

7. Design Standards - Design standards were developed from Montana Highway Commission Standards and AASHO policies.

8. Construction Cost Estimates - Comparable cost estimates for all phases of construction, including approximate estimates for major items, are included in the estimates.

9. Economic Analysis - A road user benefit analysis was made for each route for the purpose of determining and justifying the recommended route. The results are reported herein.

10. Stage Construction - Recommendations for staging construction were made to aid in the preparation of final plans.

SUMMARY

The purpose of this study was to determine the most desirable location for Interstate Route 90 from a point west of Drummond to a point just west of Nimrod. In order to study all the feasible alignments in this area and to arrive at some conclusion as to the best location and alternate for the highway, it was decided that the Digital Terrain Model Design System (described in the section entitled "General Procedure") would quickly fit the needs in determining the recommended alignment.

The design standards for this study were taken from AASHO and the Montana Highway Department criteria. The design speed used for determining horizontal and vertical alignment was 60 mph for the freeway and 30 mph for crossroads and 25 mph for frontage roads. The typical roadway and bridge sections developed for this project are consistent with the Montana Standards for Interstate projects.

Shown on the exhibits are various alignments and alternate sections which were studied. Of these, two, one north, and one south of the NPRR and CMSP & P RR were found to be worthy of further investigation.

The two routes were studied independently to determine the best line and grade for each. Taken into consideration were earthwork volumes, bridges, drainage, soils and geology, and right-of-way.

The two lines were compared on the basis of drainage, bridges, right-of-way, road user costs, and construction costs. Right-of-way estimates were prepared and furnished by the Montana Highway Department based on the location of the recommended study routes.

The cost estimate for Route 1 (the north alternate) is based on U.S. 10 and 12 remaining open after construction as a frontage road. Portions of the road may be closed but this decision will be made in the preliminary and final design phases. The additional cost of providing the frontage road from Station 0 + 00 to Station 185 is $320,000. Interchanges are provided at Bearmouth and Rattler Gulch allowing access to properties on both sides of the line. Opposite Stations 100 to 200 on line 1 south of the railroads, access roads are assumed to be graded and provided with a gravel surface in order to maintain complete access to properties on both sides of the recommended route.

It was found that line 1 had flatter grades, lower construction costs, and a higher benefit ratio than its counterpart to the south; consequently, it is recommended that line 1 be used for the development of contract plans for this section of Interstate Route 90.

DESIGN STANDARDS

The following design criteria developed for this project, I-IG-90-3 (4) 132, have been derived from the "Geometric Design Standards for the National System of Interstate and Defense Highways" which were approved by the American Association of State Highway Officials and adopted by the states on July 20, 1956. The publication, "A Policy on Geometric Design of Rural Highways," by the AASHO in 1954, and standards set forth by the Montana Highway Commission, were used for all features of design required, but not specifically outlined in the above mentioned Interstate standards.

Design Speed

Freeway	60 mph
Ramps	45 mph at exit and entrance terminals
Crossroads	30 mph
Frontage Roads	25 mph

Maximum Horizontal Curvature

Freeway	5° 00'
Ramps	10° 00' at exit and entrance terminals
Crossroads	23° 00'
Frontage Roads	25° 00'

Spiral Length

Freeway	0° - 1° 30'	None required
	1° 30'	175'
	2° 00'	225'
	2° 30'	275'
	3° 00'	325'
	3° 30'	350'
	4° 00'	375'
	5° 00'	400'
Ramps, Frontage Roads and Crossroads		None required

Superelevation

Maximum rate .08 ft./ft.

Design Vehicle

The C50 design vehicle shall govern intersection design.

Gradients - Maximum

Freeway		6% Maximum
Ramps	(Ascending)	7% Maximum
	(Descending)	6% Maximum
Crossroads		6% Maximum
Frontage Roads		10% Maximum

Vertical Curves

Freeway	800' Minimum Length
Ramps	200' Minimum Length
Crossroads	200' Minimum Length
Frontage Roads	200' Minimum Length

Structural Typical Sections

See Exhibit 4

Surfacing

See Roadway Typical Sections - Exhibit 3

Drainage Design Criteria

Large and small drainage structures will be designed as outlined in the Montana Highway Department field and office standards. The Bureau of Public Roads "Highway Drainage Manual" will be used as a guide.

Minimum diameter of pipe culverts under freeway and median ditch drains will be 24". Minimum diameter of pipe culverts for ramps, intersecting roads, and frontage roads will be 18".

For drainage areas over 10,000 acres, a special curve reflecting recent runoff experience will be furnished by the Hydraulic Engineer of the Montana Highway Department.

Structure Loading

Interstate Highway Structures - H20-S16 modified for military vehicles.
Primary or Local Highway Structures - H20 - S16.

Minimum Vertical Clearances

Local road under the Interstate Facility	14' 4"
NPRR under	23' 0" plus 0' 6" future track adjustment
CMSP & P RR under	26' 0" plus 0' 6" future track adjustment
Channel under	3' 0" minimum clearance over high water

DESCRIPTION OF ROUTES STUDIED

In the preliminary studies, various alignments and alignment combinations were considered. After a period of analysis on each alternate alignment, all were abandoned for one reason or another except for two, which were considered for this report.

Route 1

Route 1 is shown on Exhibits 5 to 11 inclusive. Route 1 begins approximately 1 mile west of Nimrod and just north of the NPRR. From Station 0 + 00 to Station 185 + 00 the line parallels the railway. A frontage road replacing U.S. 10 and 12 in this area was provided at an additional cost of $320,000.

At Station 185 + 00, a bridge crossing over the Clark Fork River is provided. From this point the line transitions from two 24' roadways and an 8' median to two 24' roadways and a 46' median.

The line primarily goes in an easterly direction towards Drummond and remains north of the NPRR throughout the study area. From the Clark Fork crossing to the proposed diamond interchange at Bearmouth, several channel relocations must be made. At Station 420±, U.S. 10 and the channel are relocated to the north to allow room for the Interstate Facility between the railway and Clark Fork. At the Bearmouth Interchange, the median narrows to 8' and remains a constant width up to the proposed diamond interchange at Rattler Gulch with U.S. 10 and 12, where it again becomes 46' wide.

From Bearmouth to the next bridge crossing of Clark Fork at Station 772 + 50 the line passes through several narrow spots where the existing channel and U.S. 10 and 12 must again be relocated to the north. Detailed drainage and maintenance of traffic studies were made at those points and are discussed in this report.

After the last channel relocation, the line winds around a hill in a northeasterly direction and crosses Clark Fork before proceeding east again. From the crossing of Clark Fork, the line ascends and descends on 5% grades parallel to U.S. 10 and 12 before it reaches the proposed interchange at Rattler Gulch.

In general, the line proceeds on level terrain, except at the beginning where steep side hill cuts are encountered to the north, at the channel relocations where the same side hill cuts appear, and at the end where the line enters mountainous terrain.

Route 2

Route 2 is shown on Exhibits 12 to 18 inclusive. It is a direct take off from Route 1 at the beginning of the study and crosses over both the NPRR and CMSP & P RR.

Proceeding east, the line crosses Clark Fork at about Station 100. At this point, ascending and descending grades of 6% are utilized to cross Medicine Tree Hill where a 200' cut is encountered.

Up to Station 250, the line consists of two 24' roadways and an 8' median, whereupon at this point the median widens to 46'. The line then proceeds in an easterly direction between two power lines. After passing over a hill and traversing some utilities, the line continues to the south of the CMSP & P RR.

At Bearmouth, a diamond interchange is provided with Old Mullan Road. Proceeding easterly, the line passes through a deep cut and emerges south of and parallel to the railroads. At Station 733 + 60, Route 2 crosses over the railroads at a 45^{o} skew and proceeds in a northeasterly direction along the base of a high hill.

The line then crosses Clark Fork and ascends the side of a hill on a 5% grade parallel to existing U.S. 10 and 12. After its descent on a 5% grade, the line forms a diamond interchange with the relocation of U.S. 10 and 12.

From Station 430 to the interchange with U.S. 10 and 12, an 8' median is proposed, and from this point to the end of the study, a 46' median is used.

Route 1-B

Route 1-B is coincidental with Route 1 up to Station 185 where it diverges to the north and crosses the NPRR and CMSP & P RR at a 45^{o} skew. At Station 250, it merges with Route 2. Route 1 was found to be superior to the 1-1B-2 combination.

Route 2-A

This route is a variation of other alignments and combines features in both Routes 1 and 2. It is coincident with Route 1 up to Station 360 where it crosses both railroads at a sharp skew. It avoids some utility locations but creates several channel changes prior to crossing the railroads.

In view of the location for the railroad crossing and unnecessary channel changes which could have been eliminated by crossing at the same point as Route 1-B, it was decided that Route 2-A would not be considered any further in this study.

Route 2-F

This route is an alternate crossing to Route 1-B with a sharper skew. It also interferes with utilities to a greater extent and for these reasons, Route 2-F was eliminated from further study.

Routes 3 and 5

Routes 3 and 5 are alternate alignments to Route 2. They are integral parts of Route 2 from the beginning of the study to the crossing of Clark Fork at Station 100. At this point, Route 5 separates from Route 2 going between Medicine Tree Hill and the CMSP & P RR. At this point, Route 5 encounters extremely high side hill earthwork volumes. At Station 200, Route 5 merged with Route 4.

Route 3, after passing through a deep cut with Route 2 at Station 210, diverged to the north along the CMSP & P RR where it merged with Route 4.

Due to the extremely high earthwork volumes on Route 5, it was eliminated from further consideration. Route 3 is a slight variation of Route 2 and it should be considered as such.

Route 4

Route 4 is coincident with Route 1 up to Station 50 where Route 4 departs from Route 1 and crosses over the two railroads and Clark Fork. It passes through Medicine Tree Hill with a depth of cut in excess of 200'. From Station 190 to Station 440 where it joins line 2, Route 4 remains a fixed distance south of the CMSP & P RR.

The long structure over the railroads and excessively high earthwork volumes prohibits any further work on this alignment.

Routes 2-B, 2-C, 2-D, and 2-E

These routes are short alternate alignments to Route 2. Each alignment considered reduces the overall length of Route 2 but, because of much higher earthwork volumes and a cost benefit analysis showing alignment 2 to be better overall they were eliminated from further study.

Route 6

The same applies to Route 6 as to Routes 2-B - 2-E,inclusive. Along with higher earthwork volumes it crosses more utility lines and therefore, it too was no longer considered.

Route 1-C

Route 1-C is an alternate to Route 1 and runs along the NPRR from Station 730 to the interchange at Rattler Gulch. This particular alignment is shorter than the same section of Route 1, but a cost benefit analysis indicates that Route 1 is more desirable than Route 1-C.

Route 1-A

Route 1-A is an alternate section to Route 1 between Station 430 and 530. It stays along the NPRR necessitating a longer roadway and does not provide an area for development of the diamond interchange at Bearmouth. The abcve shortcomings of Route 1-A necessitated its removal from further study.

GENERAL PROCEDURE

Detailed topographic maps were prepared at 1" = 500' with a 10' contour interval for the area along U.S. 10 and 12 between a point approximately 1 mile west of Nimrod and a point approximately 3 miles west of Drummond.

In order to study all possible route locations in the area, the Digital Terrain Model Design System in conjunction with the IBM 1620 was used. With the programs in this system, it was possible to study many alternate route locations. The system is divided into four phases, three of which were used in the preliminary studies. Each phase is supplemented with one or more computer programs, as follows:

1. Terrain Preparation

   In this phase, a preliminary base line was set in the general location of the proposed study area and cross sections were taken every 250' at a band width between 2000 and 6000 feet. The computer program edits the terrain data.

2. Alignment Design

   This phase computes the various roadway alignments with reference to the base line. It also prepares a profile plot which plots characters for the existing ground line along the proposed centerlines.

3. Roadway Design

   The roadway design portion of the program computes vertical alignment, earthwork volumes, mass haul ordinates and slope stake locations. It also prepares character plots of the slope stake locations and mass haul diagram.

This system enables horizontal and vertical changes to be made in the alignment and grades with a minimum of computations.

After locating the base line adjacent to the railroad, cross sections were taken every 250' and points of maximum cut and fill. The terrain data taken from the maps was then edited on the computer to insure accuracy in the manual operations of pick-off and keypunching.

Several preliminary alignments were then placed on the mapping in desirable locations. These alignments were both north and south of the railroads with railroad crossings at various locations. By feeding into the computer coordinates of the P.I.'s and degrees of curvature for each of the alignments, the computer produced an output consisting of computed alignments, stationing, offset from the base line, centerline and edge of shoulder ground elevations, and a profile plot of the ground line along the centerline of each alignment.

This data output was then utilized to set proposed profile along the most desirable alignments keeping in mind a minimum clearance above flood water depth. Preliminary investigations indicated that high water was approximately 3' below top of rail elevation, consequently, centerline profile was set at or slightly above top of rail elevation.

The input for phase three of the DTM Design System included vertical P.I. locations, elevations, and curve lengths, and roadway templates.

From the above input, earthwork volumes, percent grades, mass haul ordinates and slope stake locations were computed for each preliminary alignment. Grade line changes and horizontal shifts in the alignments were made to determine the best locations and earthwork balances for the final location studies.

In the initial phase for preliminary line and grade studies earthwork quantities were considered to be of prime importance in determining the most and the least desirable lines.

Construction cost estimates were then made on all pertinent items to determine the two best lines that would be used in the final line comparison study.

Initially, transverse drainage problems were not of prime importance, as both lines considered for further studies encountered similar drainage problems. The problem of greatest importance occurred on Route 1 where Clark Fork had to be relocated in several areas. These drainage studies are discussed in more detail elsewhere in this report.

Major structures were considered in all preliminary cost estimate studies. Unit prices per square foot, obtained from the Bridge Division of the Montana Highway Department, were used for the determination of major structure costs. Table 3 lists all the costs and Exhibit 4 shows the bridge typical sections for all major structures.

Right-of-way did not become an important factor until the final line comparison was made. In general, a 300 foot strip would be acquired except in those areas where deep cuts and fills, interchanges, channel changes or frontage roads dictated wider strips of right-of-way. In many instances, particularly on line 1, the roadways were adjacent to the railroads where a 50' right-of-way strip was maintained between the toe of the slope and centerline of the railroad.

Access problems were studied in detail on both routes. Where possible interchanges and frontage roads were provided for access. When it became economically unfeasible to provide service, additional values were added to the right-of-way costs. Right-of-way estimates were prepared by the Montana Highway Right-of-Way Department. These estimates were based on the locations of the recommended alignments assuming that access would be provided throughout.

A tabulation of bid prices for the calendar year 1961 supplied by the Montana Highway Department was used in preparing preliminary cost estimates.

Highway lighting and signing was not a major item but lump sum prices were used in the construction cost estimates to make them more complete.

Utilities were considered a major item on Route 2 which would traverse three power lines, several gas and oil pipelines, and a telephone line. Line 1 would cross telephone line and pipelines. The utilities dissected the area in several places and were avoided as much as possible, but where they were disturbed approximate costs of relocation were included in the cost estimates.

A road user analysis was made on several alternate sections to lines 1 and 2 to determine the most desirable alignment for each route. The road user costs as shown in the 1960 AASHO publication "Informational Report by Committee on Planning and Design Policies on Road User Benefit Analysis for Highway Improvements" were used. An average of traffic volumes was used of the design year 1975 and 1958, the year for which traffic was provided by the Montana Highway Department.

After the most desirable location for the line between Nimrod and Drummond was determined, a study to decide on staging of construction had to be made. The project was split into two parts of reasonable length and cost. This enabled programming for a construction schedule that would fit into future highway improvement programs for this area.

BRIDGES

Small scale layouts were made for the various structure sites to determine the overall length and the most suitable span arrangement based on the bridge plans and sections shown in Exhibit 4.

The majority of the structures was found to require only relative short spans which, based on recent experience in the State of Montana, fall well within the economic range of precast prestressed beam construction. There are, however, two structures, both occurring in line 2, which, partly because of the great skew of the intersection, necessitate longer spans. For these structures, plate girders were found to result in the most economical solution.

Unit costs were determined by applying the latest schedule of unit prices, as furnished by the State of Montana, to the large number of comparable structures for which final plans and quantities are available. In prorating the total structure cost to the deck area, the latter was taken as the product of the distance back to back of abutment walls and the clear width between curbs.

For structures which have an 8' median, the width upon which the cost estimate is based has been taken as the clear width between curbs plus an additional 5' which represents that portion of the total median which is in excess of the 1' 6" safety curbs.

The resulting structure costs are shown in Table 3. Structure types other than prestressed concrete are described in the footnotes.

SOILS AND GEOLOGY

Purpose and Methods of Soils and Geologic Study

A reconnaissance study of the Bearmouth (East-West) area was made for the purpose of determining general soils and geologic conditions within the region and the effect which these conditions might have upon location, design, construction and future performance of alternate roadway locations within the project limits. A previous geologic study of the region made by the State Highway Department was fully utilized in order that this reconnaissance could be more directly concerned with conditions encountered by the most feasible routes under study.

This study was performed through photo-geologic interpretation techniques, using photos of 1:24000 and 1:12000 scales. Reference to available publications provided petrographic background and additional information. A brief field reconnaissance served to verify and supplement the general predicted conditions with direct observation of soil and rock character and attitude. Geologic conditions along the feasible routes are shown in Exhibits 19 - 22 of this report.

Results of the Reconnaissance Study

General Background

Physiographically, the immediate region with which the route location study is concerned is located within or adjacent to the moderately developed stream valley of Clark Fork. The uplands flanking this valley are composed of a complex body of igneous, metamorphic and sedimentary rocks. Folding, thrust and normal faulting, unconformable contacts, and more recent weathering and glaciation effects characterize the mountainous terrain adjacent to the valley.

The geologic structure of the area may be divided into two major regions. From the west end of the project to Bearmouth, one major structure exhibits primary control. This is a large thrust fault which generally parallels the valley and has thrust pre-Cambrian rocks from the south over younger sediments on the north. The present erosion surface indicates differential occurrence of the effected rocks, as shown on Exhibit 20. Associated with the major structure are numerous smaller faults and severely fractured zones, generally occurring normal to the major axis.

East of Bearmouth, the geologic structure changes to a series of extremely tight and overturned folds with associated normal and thrust faulting. Upon the irregular erosion surface thus formed are various stages of volcanic flows.

Route Analysis

The basic considerations involved in the geologic analysis of alternate routes in this study are the required back slopes for stable cuts and the resulting effects on earthwork volumes. Exceptions to these basic criteria are noted in the following descriptive analysis.

Line 1 traverses a location north of the railroads for the entire project, and line 2 crosses over the railroads at the project beginning and remains south of the railroad to a point approximately three miles from the east project terminus where it crosses to the north.

Line 1

From Station 0 + 00 to Station 12, the roadway is graded from the present location of U.S. 10 into fill over recent alluvium. At Station 12, the alignment incurs a cut on the left through somewhat fractured, thin-bedded argillite and quartzite, covered with 15 to 20 feet of silty gravels to approximate Station 19 where a fault zone occurs. The sedimentary rock in this area is severely fractured and dips generally toward the roadway between 28 and 32 degrees; water is seeping from the overburden-rock contact. The rock cut must be designed on the bedding planes to avoid a dip slope failure, and a slope of 1-1/2:1 will approximate this. Beyond the fault zone in this cut is an igneous formation which, near the fault zone is severely weathered. East of Station 21 to the end of cut at Station 26, the formation is sufficiently hard to warrant a 1:1 cut slope (or on one of the controlling joint planes dipping 40 degrees to the south), with slope rounding in the overburden soils.

Beyond this cut, the alignment is in fill over recent alluvium to approximate Station 77 where a 25 foot centerline cut indicates the left cut slope to be in thin-bedded argillite, quartzite and shale extending to Station 83. This rock, capped with 5 feet of overburden, dips toward the roadway at 31 to 35 degrees, steepening to 44 degrees in the east end of cut. Because of the well defined partings, this rock will have to be cut on the controlling dip slope to insure stability.

Beyond this region to Station 118, with the exception of a possible small left side cut at Station 90, the roadway is in fill over recent river gravels. This cut at Station 90 will occur in very hard latite talus and should stand on 1-1/2:1. Below any loose material, the apparently hard parent rock will stand a cut of 1/2:1.

From Station 118 to Station 143, the alignment enters an intermittent left side cut through hard, crystalline limestone and colluvial materials. Up to Station 122, where a brecciated fault zone occurs, this rock dips steeply toward the west indicating a probable stable slope of 1/2:1. Beyond the fault zone, the dip changes to about 42 degrees south. Backslope warping to 1:1 at Station 122 and to 1-1/2:1 at Station 126, the beginning of colluvial rubble, should give a stable section.

Additional cut is indicated from Station 174 to Station 185 for line 1. This entire cut is in massively bedded quartzite, with thin shale and argillite beds. Extremely undesirable dip slopes of 30 to 35 degrees toward the roadway indicate the necessity of maintaining the cut slopes on the dip planes for stability. Several fault and fracture zones occur in the cut, but are not expected to affect stability at the slopes required. Approximately five to ten feet of soil and weathered material cover the intact rock throughout this cut.

The alignment closely parallels the NPRR on the north side from Station 185 through Station 373 and is entirely on fill over recent stream gravels. Throughout this section, three channel changes will be required by the alignment location. The velocity and gradient of the Clark Fork indicate that slope protection will probably be required in these and all subsequent channel relocations in unconsolidated material. Excavation will be entirely within the river gravels, and between Stations 373 and 388, a minor roadway through-cut will encounter terrace gravels. From this point through Station 623, no additional mainline cut is encountered. Embankment construction will be over river gravels and silts and a portion of Madison Limestone in the vicinity of Station 565.

However, channel changes and relocation of U.S. 10 require some consideration within the above limits. Between mainline Station 417 and 433, channel relocation will encounter rock excavation varying from quartzite and shale to basalt. From Station 417 to 426 left side cut will encounter massively bedded quartzite with shale partings. The attitude of this rock should permit at least a 1:1 cut slope for the channel in this area. Beyond this region, normal alluvial gravels and weak basalt are crossed, indicating a probable slope of 1-1/2:1.

From mainline Station 416, the left lane of relocated U.S. 10 will cut into thin bedded quartzite and shale to the fault zone at Station 418 + 50, beyond which the rock becomes more massive. A 1-1/2:1 slope is indicated to Station 418, with a gradual left side warping to 1/2:1 at Stations 419 through 428. Beyond this, a 1-1/2:1 slope should be used because of the apparent weakness of the rock.

The channel relocation between Stations 520 and 555 will be in stream gravels from Station 520 to Station 535. From Stations 535 through 540, lake bed silts and gravels overly stream deposits, and no change in excavated cross section is anticipated. Beyond this and extending to Station 547 left side excavation is expected to be in massive Madison Limestone, and 1/2:1 slopes should be adequate. A somewhat shorter rock excavation is anticipated for right side cut. The remainder of excavation will encounter river gravels. Similar cut slopes are expected for U.S. 10 relocation in this area, with a 15 to 20 foot bench in cuts exceeding 60 feet and the possible use of a wide ditch section for rock fall catchment.

Similar rock cut design may be used from Station 570 to Station 600 for relocated U.S. 10, where Madison Limestone is encountered predominantly in the left cut, and for channel relocation (left bank) between Stations 580 and 600.

Between Stations 623 and 628, a minor mainline cut through lake bed silt and clay will require a 2:1 slope for stability. Between Stations 646 and 676, additional channel change and U.S. 10 relocation will encounter partial rock excavation in which favorable dips occur. The interbedded limestone and shale dips southwest from 52 to 76 degrees. From these dip slopes a design of left cut slope of 1/2:1 from Station 657 is anticipated. Beyond approximate Station 665 a gradual warp to 1:1 should occur for dip stability. A slope of 1:1 should be maintained throughout the rock cut for right side design.

From Station 687 to Station 696, the roadway encounters cut in lake bed silt and clay and shales dipping 45 degrees southeast. Up to Statinn 691, a 2:1 slope is warranted; beyond this, a warp to 1:1, on the dip should be satisfactory.

Between Stations 715 and 724, a channel relocation encounters lake bed soils. A 2:1 slope appears justifiable throughout the cut. Beyond Station 740, line 1 becomes coincident with line 2 to the project terminus. Lake bed and alluvial soils are encountered in cut from Station 757 through Station 765, where a calcareous shale and sandstone occur, dipping west at 25 degrees. A 2:1 slope is recommended for all left side cuts to insure stability of lake bed soils and the unfavorable dip of the rock. A 1:1 slope should be satisfactory for right side rock.

From Station 784 to Station 790, minor rock cut is indicated in a sandstone-shale sequence, dipping southwest at 46 degrees. A 1:1 slope is suggested for both sides of the alignment through this zone of rock. Beyond this cut section, alluvial gravels are expected to the extent of cut depth through Station 805 and 1-1/2:1 slopes should be used. At this location, the cut increases such that the sandstone-shale-limestone beds of the Swift and Rierdon formations will be encountered below the average 10 to 15 foot thick gravel overburden. Between Stations 811 and 815, these formations are exposed at surface and no overburden is expected. Normal 1:1 cut slopes should conform to the expected dips in this area, beyond which the alignment is in fill over quaternary and recent alluvial soils to the project terminus.

Line 2

From its coincident location with U.S. 10 and line 1, this alignment swings south and crosses the railroads at Station 30, maintained on fill through Station 125; however, a channel relocation is necessary, and quartzite-argillite talus and sound rock may be encountered between Interstate Stations 60 and 70. The ground slope on the south, with in-situ rock dips of 24 degrees to the south, now stands at nearly 45 degrees, indicating a probable right side rock cut slope of 3/4:1 to 1:1 with a talus cut slope of 1-1/2:1.

Between Stations 125 and 142, line 2 is located through Medicine Tree Hill in formations of dipping argillites and quartzites and a massive latite flow. Extremely undesirable dip slopes (on the order of 25 degrees) are expected for left side cut slopes in the initial 400 to 500 lineal feet of cut, and a 2:1 slope is anticipated for stability requirements.

A 1:1 slope should be satisfactory for right side cut slope design in the layered rocks. Cut slopes within the latite flow are expected to be 1/2:1 for sound, in-situ rock. Benching is suggested for rock-fall catchment, especially at the contact zone between the volcanics and quartzite-argillites.

From Station 199 to Station 216, a through cut is encountered in a similar quartzite-argillite formation with dips varying from 30 to 40 degrees to the southwest. Field indications point to a possible right cut slope of 3/4:1 to 1:1, with the exception of a possible weak fault and dike zone in the vicinity of Station 212 which will require a 1:1 or flatter slope. The critical dips observed appear to indicate a beginning left side cut slope of 1-1/2:1 warping to 1:1 at the east end of the cut.

From Station 216 to Station 369, this route is entirely in fill over alluvial gravels. From this latter station to Station 373, the alignment encounters cut through a very hard fractured quartzite, with an average 10 foot alluvial cover, dipping from 35 to 40 degrees northeast. Slopes of 1-1/2:1 on the right and 3/4:1 to 1:1 on the left are anticipated. The roadway then continues in fill to Station 461, where 400 lineal feet of cut is indicated. This cut, in fractured, weathered andesite will probably require a slope of 1-1/2:1, or 1:1 in unweathered material. A minor cut in morainal soils near Station 485 will require normal overburden slopes.

Between Stations 493 and 501, additional mainline cut is indicated. Through Station 495, a 1-1/2:1 slope is required for the moraine gravels, but beyond this a 1:1 should be adequate in the andesite. At Station 511, an extensive through cut for 2900 feet is apparent from the grade line. Up to Station 517, a 1:1 slope is recommended in the andesite. Beyond this and extending to Station 527, the andesite is covered with 5 to 20 feet of moraine gravels and residual volcanic soil. It is recommended that in this area a 1-1/2:1 to 2:1 slope be maintained through the overburden soils to be separated from rock cut by a 5 foot bench, and the 1:1 rock slope be warped to 1/2:1 at approximate Station 527. From this point to Station 540, the 1/2:1 slope should be held, possibly with a widened ditch for rock-fall catchment, for a vertical height of 50 to 60 feet, whereon a 15 to 20 foot bench should be included. Above the bench a 3/4:1 to 1/2:1 slope is suggested. A talus slope in the region left of Station 534 may require some local slope flattening, and in the same area, portions of the underlying Madison Limestone may be encountered. If such a condition exists, it may be advisable to include a bench at the contact zone.

From Station 554 to Station 577, the alignment encounters substantial cut in the Madison with a thin, variable gravel cover. Throughout this hard limestone 1/2:1 slopes should be adequate for stability with the inclusion of a wide ditch, and in that portion of cut exceeding 60 feet vertical height a 15 to 20 foot bench is recommended. Between Stations 578 and 585, a minor right side cut may encounter limestone talus. A 1-1/2:1 slope is recommended in this material.

From Station 618 to Station 632, a cut traverses varved lake bed silts and andesite with 10 feet of soil cover.

A 1:1 or 1-1/2:1 slope is recommended for the weathered andesites through Station 624 for right side cut; other than this, a 2:1 overburden slope should be used.

From Station 689 to 693, a cut through lake bed soils will require a 1-1/2:1 to 2:1 slope. Beyond this, a warping of cut slopes to 1/2:1 (left side) and 1:1 (right side) at Station 696 should accommodate the limestone-shale sequence, dipping south at 71 degrees. At Station 735, the alignment crosses to the north of the railroads and becomes coincident with line 1 to the project terminus.

Construction Considerations

Probable sources of granular borrow and possible aggregate are located throughout the project in the recent alluvial deposits, quaternary alluvium terraces and morainal materials. Potential sources occur in the abandoned placer deposits of Bear Creek and other large alluvial fans. Additional sources of granular borrow are excavated cut material of the Cambrian or Pre-Cambrian quartzites, limestones, and talus deposits; and the limestones and sandstones of the Madison and Kootenai formations.

Of possible concern is the depth of organic soils and silts over the recent alluvial gravel and the effect of these soils on the extensive embankment construction throughout the project. However, it is believed that the depth of these materials over the gravels is generally negligible insofar as stability or settlement of embankments is concerned. A comprehensive soil survey, coupled with seismic investigations, is recommended in order to confirm this, as well as soil-rock and rock-rock contacts and quality-quantity relationships of anticipated borrow areas. It is recommended that a 5 foot bench be located at the soil-rock contact if the overburden depth is greater than 10 feet or if it is of such character as to jeopardize maintenance of the cut section.

The ratio of rippable rock to rock requiring blasting is quite variable throughout the project. The ratios of these quantities have been estimated for individual cuts based on field observations and the notes of the previous State Highway Department geologic study. Estimated unit prices for unclassified excavation and rock excavation have been applied respectively to the approximated quantities of overburden and rippable rock, and blasted rock. From this compilation, estimated average excavation costs for each alignment have been computed. With regard to all lines, it can be generally assumed that the more massive sandstones, argillites, quartzites, limestones, and deep andesites will require blasting. The occurrence of these rocks is indicated on Exhibits 19 - 22 and in the foregoing text.

In particular, all andesite encountered in line 2 between Stations 510 and 540 is expected to require blasting, as will all Madison Limestone excavation for line 2 and relocated U.S. 10 in the same region. Blasting on line 2 in this area will require special precautions because of railroad proximity. Relocation of U.S. 10 and the channel changes in this area and several other areas along the project will have to be accomplished prior to Interstate construction on line 1, thereby indicating a problem of traffic maintenance.

In this same "gorge" area, it is noted that the high limestone cliffs on the south side of Clark Fork prevent sunlight from penetrating to the proposed location of line 2. The presence of perpetual warm springs in the gorge limestone reportedly causes intense fog in the area during cold months. This fog will create a severe icing problem on the pavement unless it is warmed by sunlight, whereas line 1 location will receive at least partial sun during winter months.

Conclusions

From a geologic standpoint, both alignments are entirely feasible, although more mainline rock cut and structures are anticipated for line 2; whereas, critical dip slopes control the majority of cut slopes on line 1, and significant U.S. 10 relocation and channel changes are necessary. Then, cost comparison, earthwork balance, and maintenance become critical factors in alignment choice, and it would appear that line 1 is more desirable from the standpoint of Interstate location.

Subsequent to the choice of a firm line, a survey encompassing a boring program with concentrated reconnaissance and seismic investigations is recommended to verify anticipated overburden thickness, depth of weathered rock, and extent of fracturing in deep cuts. At this time, benching criteria, where applicable, and cut slope design may be refined, should the results of the investigation indicate other than expected conditions.

Varied cut slope designs have been considered for the cuts throughout the project since no two cuts are alike with respect to rock type and attitude. Generally, in thin-bedded or otherwise competency controlled rock strata, dips exceeding 20 to 25 degrees will determine the critical design cut slopes for stability. The cut slopes indicated for beds dipping toward the roadway are entirely controlled by the rock attitude and competency in this position, as shown on page 21 . For rocks dipping away from the roadway, cut slopes are controlled by normal flat lying competency of the formation or by the competency of the major rock exposed.

This report has been generally concerned with normal cut slope nomenclature; i.e., 1-1/2:1, 3/4:1, etc., for ease of preliminary estimating and computation. However, good design and construction techniques will necessitate minor field adjustment of critical on-dip slopes to conform to true dip angles for satisfactory cut performance. In some cut areas, the inclusion in the roadway section of a widened ditch will facilitate maintenance and eliminate possible rock falls onto the pavement.

For all cuts in consolidated rock, a minimum 12 inch cushion should be included beneath the pavement structure. This cushion may be constructed by undercutting the design grade and replacing with 12 inches of well-compacted suitable sub-grade material. In extensive side-hill cuts and through cuts, particularly in limestones and dipping, layered sandstones, water seepage may occur and provide a source of uplift pressures. For relief in such cases; perforated, longitudinal underdrains should be installed beneath drainage ditches. Fills throughout the project may be constructed on 1-1/2:1 slopes if sound, shot or natural angular rock fragments are used. However, recompacted soils and severely altered, soft rock will require 2:1 fill slope construction.

RECOMMENDED CUT SLOPE DESIGN CRITERIA

Material Description	Case I Bedding Dip Toward Roadway			Case II Bedding Dip Away From Roadway			Remarks
	$0-20^\circ$	$20^\circ-77^\circ$	77°	$0-20^\circ$	$20^\circ-77^\circ$	77°	
Volcanics: Andesite Basalt Latite Rhyolite	---	---	---	---	---	---	Dependent on jointing and fracturing generally 1/2:1 to 1:1; 1:1 to 1-1/2:1 if altered and weathered. Ditch widening and upslope benching recommended for deep cuts.
Quartzite-Argillite (Thin-bedded, competent formations)	1:1	On Dip to 1/2:1	1/2:1	3/4:1 to 1:1	3/4:1 to 1:1	1/2:1 to 1:1	Ditch widening recommended in deep cuts to catch loose material from seasonal weathering. Upslope benching may be necessary in Case II.
Quartzites & Sandstones (Massively bedded)	3/4:1 to 1:1	On Dip	On Dip to 1/4:1	1:1 to 1/2:1	1:1 to 1/2:1	1:1 to 1/2:1	Same as above
Massive Argillite, Hard Shale and Thin-Bedded Limestone	1:1	On Dip to 1/2:1	1/2:1	1:1	3/4:1 to 1:1	3/4:1 to 1:1	Same as above
Thin-Bedded Argillite and Soft Shale	1-1/2:1	On Dip to 3/4:1	3/4:1	1-1/2:1	1:1	1:1	Same as above
Massive Limestone	1/2:1	1/2:1 to 3/4:1*	1/2:1*	1/2:1	1/2:1	1/2:1	Ditch widening and upslope benching recommended for catchment in deep cuts. *If competency is dependent on bedding cut on dip.
Hard Rock Talus and In-Situ Gravels	1-1/2:1	---	---	1-1/2:1	---	---	---
Overburden Soils	2:1	---	---	2:1	---	---	---

FINAL LINE COMPARISON AND RECOMMENDATION

In the previous sections, it was shown that lines 1 and 2, north and south of the NPRR and CMSP & P RR were found to be the most desirable alignments between Nimrod and Drummond. It then became necessary to make a final comparison between these two lines to determine the most desirable of these two. The various comparisons that were made are discussed in the following paragraphs.

Length

There is very little difference in length between the two lines. From the beginning of the study to the end, the lengths are as follows:

Line 1	16.87 miles
Line 2	16.71 miles

Horizontal Alignment

To compare the geometry of one line to another the following comparisons were made:

1. A summation was made of all central angles on each line without regard to direction or degree of curvature. These were converted to total central angle per mile by use of the mileages in the previous section. The results are as follows:

Line 1	944° 19' Total Central Angles
Line 2	915° 23' Total Central Angles
Line 1	55° 57' Per Mile
Line 2	54° 47' Per Mile

2. The number of horizontal curves on each line was tabulated and converted to number of curves per mile.

Line 1	20 Total Curves
Line 2	22 Total Curves
Line 1	1.18 Curves per Mile
Line 2	1.32 Curves per Mile

From the above comparisons, it can be concluded that line 1 is essentially the same as line 2 with respect to horizontal alignment.

Vertical Alignment

A comparison of grades on the two lines follows:

Line 1

0-3% Grade	16.02 Miles
3-5% Grade	0.43 Miles
5-7% Grade	0.43 Miles

Line 2

0-3% Grade	13.30 Miles
3-5% Grade	1.54 Miles
5-7% Grade	1.87 Miles

The above tabulation indicates that line 1 grades are flatter than the grades on line 2.

Traffic Service

At present U.S. 10 carries approximately 1850 vehicles per day between the project limits. With the construction of lines 1 or 2, all the traffic will be diverted to Interstate 90 with the exception of those desiring local access in the area. The Montana Highway Department suggested the use of a 2.56 expansion factor for this area for the design year 1975 which would assign 4700 ADT to the Interstate Route.

After construction of Interstate 90, U.S. 10 will serve as a local access road to abutting properties. It was assumed that diamond interchanges would be provided at Bearmouth and Rattler Gulch in this reconnaissance study.

Maintenance Costs

Table 4 shows the maintenance costs of each line to be approximately equal. Interstate preliminary estimates per mile for maintenance do not take into consideration snow and ice removal. There would be more snow and ice removal on Route 2 because of its proximity to the high hills, which would tend to shield the sun.

Road User Costs

The method for obtaining road user costs on Routes 1 and 2, and U.S. 10 is described in a previous section entitled "General Procedure". As noted in Tables 5 and 6, the road user costs for line 1 are approximately equal to those for line 2.

Total Cost Estimates

Detailed cost estimates for both lines are shown in Tables 8 and 9 and are discussed in a subsequent section entitled "Construction Cost Estimates.

Fifteen per cent of the construction cost was added to the estimate to cover the cost of engineering and contingencies.

Engineering items are design surveys, subsurface investigations, preparation of construction plans, special provisions, cost estimates and contract documents; bid analysis, supervision of construction, inspection of materials and workmanship, and scheduling and coordination of construction and material contracts. Included under contingencies are items uncertain as to occurrence and miscellaneous minor items not included elsewhere.

A comparison of the cost estimates of the two lines indicates that line 2 is much more expensive than line 1.

Benefit Cost Analysis

For this study, a rate of interest of 4% was used, and the years of life for the various highway construction items were assumed to be as follows:

Right-of-way	50 years
Grading (including excavation, minor structures and clearing and grubbing)	40 years
Surfacing (including surfacing, guardrail, and signing and lighting)	20 years
Major structures	40 years

Lines 1 and 2 were compared to present U.S. 10 which was assumed to be the basic condition. The benefits to be derived from money spent on line 1 are sufficient to justify the expenditure.

Route Recommendations

By analyzing the above considerations, one of the two lines considered as alternates can now be established as the preferred route.

With respect to length, line 2 is 0.16 miles shorter than line 1, which is not to be considered an important factor.

The horizontal alignment is about equal on both lines but line 1 is superior to line 2 with regard to vertical alignment.

Of prime consideration is the initial cost of construction of each route. As shown in Tables 8 and 9, the cost of line 1 is about $2,500,000 less than line 2.

An important consideration in choosing a route is the road user benefit analysis. Benefit-cost ratios were calculated and Table 10 shows that line 1 is preferable to line 2 both in the first and second benefit analyses.

During construction, difficulties would arise on line 1 due to its proximity to U.S. 10. On line 2, U.S. 10 would not be disturbed. Elaborate detours would not be necessary during construction of Route 1 but considerable delays would result.

After reviewing the foregoing considerations, it can be concluded that Route 1 is superior to Route 2.

DRAINAGE

Drainage studies along the proposed routes were conducted using U.S.G.S. maps and hydrologic survey data, aerial photo contour mapping (10' contours, scale 1" = 500'), Montana State Highway Department survey notes and plans for U.S. 10, Northern Pacific and Milwaukee Road railroad plans and notes, and limited field reconnaissance. The U.S. Bureau of Public Roads Drainage Manual and the Burkli-Ziegler method were used to determine runoff and comparisons were made with existing structures, wherever possible, to arrive at proper sizing of waterway openings. The basis for runoff calculations was a 50-year frequency design storm.

Final design studies will be based on detailed field survey information for the selected route. For drainage areas over 10,000 acres a special curve reflecting recent runoff experience will be furnished by the Hydraulic Engineer of the Montana Highway Department.

Structures will be designed as outlined in the Montana Highway Department Field and Office Standards and as directed by the Hydraulics Section. Minimum diameter of mainline pipe culverts and median ditch drains will be 24 inches. Minimum diameter of pipe culverts for ramps, intersecting roads and frontage roads will be 18 inches.

Irrigation ditches will be relocated as required to preserve the existing system in cases where such preservation is economically warranted. In general, existing drainage patterns will be maintained, subject to engineering and economic analyses, weighing the advantages of present patterns against those of potential revisions. In every case, designs will be calculated to avoid flood damage to the highway or adjacent property, within the limits of economic feasibility.

Special calculations were made for channel relocations of the Clark Fork River. Discharge records for the Clark Fork were obtained from Geological Survey Water Supply Paper 1316, "Surface Waters of Pacific Slope Basins in Washington and Upper Columbia River Basin." These were extrapolated to produce a discharge curve through the area of study. From this determination of discharge, a channel design was formulated capable of handling the peak flood of record, with an additional emergency safety factor provided by the height of roadway subgrade above the berm.

Field surveys were made along the channel at locations where anticipated channel relocations would be made. Channel bottom and top of water profiles were taken along with cross sections of the channel. Using the slope data obtained from the field and variable values of "N", depending on existing conditions, along with the flood design value for "Q", a maximum height of flood was determined. From this information, it was found that a 100' channel bottom and 11' height to the top of the berm would be sufficient to handle maximum flood conditions. This cross-section was based on the flattest channel slope found at the different survey locations, which tends to yield an additional safety factor.

The existing railroad bridges over Clark Fork at Station 184 and 790 right have four 75' spans and are on a 45° skew. The proposed Interstate bridges over Clark Fork were designed with the same waterway opening. A more detailed study of these bridges will be made during preliminary and final design.

CONSTRUCTION COST ESTIMATES

In order to arrive at an accurate cost estimate for both lines it was necessary to determine suitable unit prices for each item as well as to determine the total quantities with reasonable accuracy. The unit prices and their derivation are discussed in detail in the following paragraphs.

Clearing and Grubbing

The tabulation of 1961 average low bid prices for Montana lists clearing and grubbing at $600 per acre. This price is based on 54 acres, and since both lines 1 and 2 have between 250 and 300 acres, it is reasonable to assume a lower unit price should be used. Therefore, it was felt that a price of $500 per acre would be reasonable.

Excavation

Excavation figures and the component items making up the grading and earthwork estimates were developed to cover all conditions on both lines. A Geological study of various areas indicated that the steepest cut slopes that would be anticipated would be approximately 1/2:1. Investigations of each area in cut were made to determine the steepness of each cut slope, the benching required, the amount of overburden, and percent of rippable rock below overburden.

With the above information, approximate unit prices for each earthwork item could be found. A weighted average unit price for unclassified excavation was estimated by using an approximate percent of non-rippable rock and earth determined from studies and applying a unit price of $0.33 per cubic yard to earth and rippable rock and $1.25 per cubic yard to non-rippable rock. The approximate percent of non-rippable rock on line 1 is 36% and line 2, 39% yielding a weighted average unit price for unclassified excavation of approximately $0.66 and $0.65 respectively.

For borrow excavation, taking into account handling and overhaul, an average unit price of $0.40 per cubic yard was used.

Items of overhaul, watering, rolling, and riprap, were estimated separately using average low bid prices for the year 1961 supplied by the Montana Highway Department.

Surfacing

Pavement thicknesses and widths as shown on the typical sections in Exhibit 3 were used in converting material weights and rates of applications into total surfacing costs per mile.

Drainage

Major drainage structures, determined by drainage areas from the mapping, were computed and are shown on the plans and in Table 2.

Unit prices for each culvert were converted into lump sums to cover the cost of major drainage structures.

For smaller culverts a cost of approximately $8,000 per mile was assumed. It was felt that since this would be a small portion of the total construction cost, a detailed study of these culverts should be a part of preliminary and final design.

Miscellaneous Items

Guardrail was installed on all fills over 10 feet in height, and double guardrail was used on 8' medians.

For lighting and signing, a lump sum price of $60,000 per interchange was used. For utility relocations, topographic maps and unit prices supplied by the utility companies were used to compile a cost estimate.

Right-of-way fence for the entire length of the project was estimated in rods and average low bid prices supplied by the Montana Highway Department were utilized in estimating costs.

Complete estimates of costs were developed for lines 1 and 2. They are shown in Tables 8 and 9.

TRAFFIC

Traffic volumes for existing U.S. 10 were supplied by the Montana Highway Department along with generation factors in order to determine 1975 ADT volumes.

The average daily traffic on U.S. 10 in 1958 was 1850 vehicles per day. To project this volume to the design year of 1975, the following formula was used:

Expansion factor	=	G (1 + SLI)
where G	=	Trip generation factor
S	=	Statewide percentage traffic increase forecasted for the period from 1958 to 1975.
L	=	Factor to convert S to a particular location.
I	=	Factor to reflect more rapid rate of growth along the Interstate System.

The values that were used in this study are as follows:

G	=	1.40
S	=	0.60
L	=	1.20
I	=	1.15

The resultant Interstate Expansion Factor is 2.56

The expanded 1975 traffic volumes on the Interstate Route become 4,700 vehicles per day. Fifty vehicles per day local traffic on U.S. 10 will exist after construction of I-90.

Assuming an operating speed of 50 - 55 mph, K and T values of 15 and 10 per cent respectively, four lanes would be required for the Interstate Facility.

Relatively low traffic volumes indicate that diamond interchanges would serve adequately at Bearmouth and Rattler Gulch.

During construction of line 1 in many locations traffic would be interrupted on U.S. 10 because of reconstruction and blasting operations. A study was made of each area independently to determine the extent of construction necessary for each section of detour for maintenance of traffic. These studies and estimates of construction are as follows:

Station 0 + 00 to Station 200

Traffic on U.S. 10 can utilize the existing roadway on line 1 during excavation and blasting. With careful control of explosive charges and by the use of appropriate warning signs located away from the approaches to the blasting area, traffic will be detained a minimum amount of time.

Flagmen should be stationed at the approaches to the blast areas and direct traffic during blasting and clean-up operations.

As construction of the Interstate route proceeds, traffic can be rerouted to the Interstate roadway as U.S. 10 is removed.

The lump sum cost, for traffic maintenance including signing, flagmen, and clearing equipment is estimated to be $40,000.

Station 415 to 440

Existing Route 10 can be left open to traffic during the construction of relocated U.S. 10. Excavation necessary for the relocation will require blasting of rock north of existing U.S. 10. At its closest point such blasting activity will be within 50 feet of the edge of present U.S. 10 pavement, which condition will prevail over a length of approximately 300 feet from Station 420 to 423. The following procedures are recommended:

1. Careful control of explosive charges should be exercised to minimize the extent of rock fall so that the least amount of rock fragments, consistent with practical considerations, will fall upon existing U.S. 10.
2. Highway approaches to blast areas should have appropriate warning signs located well away from the danger zone.
3. Flagmen should be stationed on all highway approaches to blast areas. They should be provided with reliable communications to and from the blast site so that traffic may be halted before actual blasting operations.
4. Suitable rubber tired equipment should be available for the rapid clearing of any rock fragments falling upon the roadway. These could be front end loaders also usable in loading the excavated rock for removal from the site.

By following these procedures, traffic interference on existing U.S. 10 should be held well within tolerable limits. The lump sum cost for traffic maintenance including signing, flagmen and pavement clearing equipment is estimated at $5,000.

Statinn 530 to 560

Existing Route 10 can be maintained open to traffic during the construction of relocated U.S. 10.

The same precautionary measures outlined for construction of U.S. 10 relocation between Station 415 and 440 should be applied where blasting is required. Total cost of maintenance of traffic in this area is estimated at $5,000.

Station 570 to 605

Existing Route 10 can be maintained open to traffic during the construction of relocated U.S. 10 with the exception of the section opposite Station 576 to 588.

In this area, it will be necessary to provide a detour of U.S. 10 offset about 40 feet south of the existing pavement since the toe of embankment for the relocation of U.S. 10 falls on the existing U.S. 10 pavement. This detour could consist of ten inches of crushed gravel base with two inches of crushed gravel surfacing and should be 24 feet wide with four foot shoulders on each side.

The same precautionary measures outlined for construction of U.S. 10 relocation between 415 and 440 shall be applied where blasting is required. Total cost of maintanance of traffic in this area, including construction cost of the temporary relocation, is estimated at $25,000.

Station 650 to 670

Existing Route 10 can be maintained open to traffic during the construction of relocated U.S. 10 with the provision of a small amount of temporary relocation as follows:

Between Station 656 and 663	Widen 10' on south side because the excavation necessary for relocating U.S. 10 would undermine existing U.S. 10 pavement.
" " 663 and 665	Transition 10' widening to 24' detour south of existing Route 10.
" " 665 and 669	24' detour.
" " 669 and 670	Merge 24' detour to meet existing roadway.

Widening and detour composition should be the same section required between 576 and 588 with precautions for blasting operations the same as previously set forth. Total cost of maintenance of traffic in this area, including cost of widening and detour construction, is estimated at $20,000.

CONSTRUCTION PROCEDURE

Based upon the several analyses contained in this report, Route 1 has been recommended. We further recommend that Route 1 be divided into two construction sections in order to facilitate the award of construction contracts. The section limits and estimated total construction costs for each section are as follows:

Section 1	Station 0 + 00 to Station 450	- $2,745,460
Section 2	Station 450 to Station 894 + 50	- 3,835,900

The descriptions and costs of the separate phases of construction are indicated in Tables 11 and 12.

The construction sections as recommended herein are designed for completion in order of numerical sequence or for simultaneous construction. However, with simple modification they can be adapted to any sequence.

TABLE 1

CONSTRUCTION COST ESTIMATES

FOR ROUTES 1 AND 2

	Route No. 1	Route No. 2
Length (Miles)	16.87	16.71
Cost of:		
Grading[1]	$ 3,454,360	$ 5,311,050
Surfacing[2]	2,455,580	2,424,050
Structures	671,590	1,223,090
Total Cost	$ 6,581,530	$ 8,958,190

[1] Includes clearing and grubbing, earthwork, utilities and drainage.

[2] Includes surfacing, guard rail, lighting and signing.

TABLE 2

DRAINAGE RECOMMENDATIONS

LINE 1

Station	Drainage Area (Acres)	Culvert Size
380 + 00	25,635	(3) 8'-10" x 6'-1"
479 + 00	12,013	12'-10" x 8'-4"
834 + 00	9,775	12'-10" x 8'-4"
889 + 00	3,220	8'-10" x 6'-1"

LINE 2

Station	Drainage Area (Acres)	Culvert Size
377 + 50	25,635	(3) 8'-10" x 6'-1"
489 + 00	2,685	8'-7" x 5'-11"
502 + 00	9,328	12'-10" x 8'-4"
838 + 00	9,775	12'-10" x 8'-4"
892 + 00	3,220	8'-10" x 6'-1"

Cost of Major Drainage Structures -	Line 1	$79,850
	Line 2	88,390

Culverts smaller than structural plate pipe arches not considered individually but unit costs per mile for lines 1 and 2 for minor drainage structures were estimated to be $7,500 and $8,100, respectively.

TABLE 3

BRIDGE RECOMMENDATIONS

Station	Length (Feet)	Deck Width (Feet)	Deck Area (Sq. Ft.)	Cost Per Sq. Ft.	Total Cost
		LINE 1			
185 + 00	317.5	61.0	19,368	$ 10.50	$203,400
501 + 30	133.0	76.0	10,108	10.50	106,200
Mullan Road over Clark Fork	220.0	28.0	6,160	10.50	64,680
772 + 50	220.0	81.0	17,820	10.50	187,110
846 + 20	138.0	76.0	10,488	10.50	110,200
		TOTAL COST OF BRIDGES			$671,590
		LINE 2			
30 + 00**	580.0	61.0	35,380	$11.50	$406,870
100 + 00	220.0	81.0	17,820	10.50	187,110
105 + 00+	260.0	16'7" x 10'1" SPPA		140.00/1.£	36,400
509 + 55	118.0	81.0	9,558	10.50	100,400
733 + 60*	262.0	60.0	15,720	12.40	195,000
777 + 20	220.0	81.0	17,820	10.50	187,110
850 + 00	138.0	76.0	10,488	10.50	110,200
		TOTAL COST OF BRIDGES			$1,223,090

* Plate Girder Structure

\+ Structural Plate Pipe Arch Equipment Underpass

** Combination prestressed beam and steel beam construction

Prestressed Concrete I beams recommended for all other structures on lines 1 and 2

TABLE 4

MAINTENANCE COSTS

Description of Facility	Length (Miles)	Annual Cost Per Mile	Total Annual Cost
Interstate Highways			
4-Lane	16.87	$ 3,500	$59,000
Cross Roads	0.20	500	100
Frontage Roads	17.90	200	3,600
	34.97		$62,700

LINE 2

Interstate Highways			
4-Lane	16.71	$ 3,500	$58,500
Cross Roads	0.20	500	100
Frontage Roads	17.90	200	3,600
	34.81		$62,200

PRESENT U.S. 10

Primary Highway	17.9	$ 1,800	$32,200

Note: It would be necessary to resurface existing U.S. 10 if the Interstate Facility were not constructed. The cost of this operation is estimated to be 17.9 miles at $\frac{\$30,000}{\text{mile}}$ = $537,000.

TABLE 5

ROAD USER COSTS

ROUTE 1

Description of Facility	Length (Miles)	1958 ADT	1975 ADT	Ave. ADT	Equiv. No. Pass. Cars (1)	Road User Cost Per Veh. Mile (2)	Total Annual Road User Cost
0 - 3% Grade	16.02	1840	4700	3270	4090	$.0913	$2,183,500
3 - 5% Grade	0.43	1840	4700	3270	4090	.0935	60,000
5 - 7% Grade	0.43	1840	4700	3270	4090	.0967	62,100
					TOTAL		$2,305,600

(1) Assume 10% trucks and 1 truck = 3.5 passenger cars

(2) Road User Cost per vehicle mile adjusted for curvature

TABLE 6

ROAD USER COSTS

ROUTE 2

Description of Facility	Length (Miles)	1958 ADT	1975 ADT	Ave. ADT	Equiv. No. Pass. Cars (1)	Road User Cost Per Veh. Mile (2)	Total Annual Road User Cost
0 - 3% Grade	13.30	1840	4700	3270	4090	$.0913	$1,812,750
3 - 5% Grade	1.54	1840	4700	3270	4090	.0935	214,950
5 - 7% Grade	1.87	1840	4700	3270	4090	.0967	270,000
					TOTAL		$2,297,700

(1) Assume 10% trucks and 1 truck = 3.5 passenger cars

(2) Road User Cost per vehicle mile adjusted for curvature

TABLE 7

ROAD USER COSTS

U.S. 10 and 12

Description of Facility	Length (Miles)	1958 ADT	1975 ADT	Ave. ADT	Equiv. No. Pass. Cars (1)	Road User Cost Per Veh. Mile (2)	Total Annual Road User Cost
0 - 3% Grade	15.7	1840	4700	3270	4090	$.1044	$2,446,900
3 - 5% Grade	1.1	1840	4700	3270	4090	.1082	177,700
5 - 7% Grade	1.1	1840	4700	3270	4090	.1150	188,800
					TOTAL		$2,813,400

(1) Assume 10% trucks and 1 truck = 3.5 passenger cars

(2) Road User Cost per vehicle mile adjusted for curvature

TABLE 8

COST ESTIMATE

ROUTE 1

Sta. 0 + 00 to Sta. 894 + 50

Item	Unit	Quantity	Unit Price	Cost
Clearing and Grubbing	Acres	245	$500	$ 122,500
Unclassified Excavation	Cu.Yds.	3,189,100	0.662	2,111,180
Borrow Excavation	Cu.Yds.	1,409,000	0.40	563,600
Watering	M.Gals.	92,084	1.10	101,290
Rolling		11,510	7.80	89,780
Overhaul	Yd.Mi.	723,530	0.15	108,530
Rip-Rap	Cu.Yds.	5,000	5.00	25,000
4-Lane, Pav't. 46' Med.	Miles	6.9	103,200	712,080
4-Lane, Pav't. 8' Med.	Miles	9.97	96,840	965,490
Ramps	Miles	2.0	32,030	64,060
Cross Roads - Paved	Miles	0.2	29,790	5,960
Frontage Roads - Gravel	Miles	8.5	6,240	53,040
Guardrail (Double)	Lin.Ft.	52,640	5.00	263,200
Guardrail	Lin.Ft.	71,000	3.00	213,000
Minor Drainage	Miles	16.87	7,500	126,530
Major Drainage				79,850
Structures				671,590
Lighting and Signing				120,000
Utilities				31,100
Traffic Maintenance				95,000
R.O.W. Fence	Rods	10,800	5.44	58,750
		CONSTRUCTION COST		$6,581,530
Right-of-Way				212,000
Engineering and Contingencies - (15% of Construction Cost)				987,230
		TOTAL ESTIMATED COST		$7,780,760

TABLE 9

COST ESTIMATE

ROUTE 2

Sta. 15 + 00 to Sta. 897 + 50

Item	Unit	Quantity	Unit Price	Cost
Clearing and Grubbing	Acres	314	$500	$157,000
Unclassified Excavation	Cu.Yds.	5,257,000	0.65	3,417,050
Borrow Excavation	Cu.Yds.	2,640,000	0.40	1,056,000
Watering	M.Gals.	159,380	1.10	175,320
Rolling		19,920	7.80	155,380
Overhaul	Yd.Mi.	452,800	0.15	67,920
Rip Rap	Cu.Yds.			
4-Lane Pav't., 46' Med.	Miles	5.07	103,200	523,220
4-Lane Pav't., 8' Med.	Miles	11.65	96,840	1,128,190
Ramps	Miles	2.0	32,030	64,060
Cross Roads - Paved	Miles	0.2	29,790	5,960
Frontage Roads - Gravel	Miles	1.1	6,240	6,860
Guardrail (Double)	Lin.Ft.	61,510	5.00	307,550
Guardrail	Lin.Ft.	70,000	3.00	210,000
Minor Drainage	Miles	16.72	8,100	135,430
Major Drainage				88,390
Structures				1,223,090
Lighting and Signing				120,000
Utilities				58,560
Traffic Maintenance				
R.O.W. Fence	Rods	10,700	5.44	58,210
		CONSTRUCTION COST		$8,958,190
Right-of-Way				200,000
Engineering and Contingencies - (15% of Construction Cost)				1,343,730
		TOTAL ESTIMATED COST		$10,501,920

TABLE 10

BENEFIT COST STUDY

ANNUAL COSTS

Line 1

Right-of-Way	212,000 x .0465	=	$ 9,860
Grading	3,454,360 x .0505	=	174,440
Surfacing	2,455,580 x .0736	=	180,730
Structures	671,590 x .0505	=	33,920
Maintenance		=	62,700
	TOTAL ANNUAL COST		$461,650

Line 2

Right-of-Way	200,000 x .0465	=	9,300
Grading	5,311,050 x .0505	=	268,210
Surfacing	2,424,050 x .0736	=	178,410
Structures	1,223,090 x .0505	=	61,770
Maintenance		=	62,200
	TOTAL ANNUAL COST		$579,890

Present U.S. 10

Maintenance		=	32,200
Surfacing	537,000 x .0736	=	39,500
	TOTAL ANNUAL COST		$71,700

ROAD USER COSTS

Line 1	$2,305,600
Line 2	2,297,700
Present U.S. 10	2,813,400

BENEFIT COST RATIOS

Line 1 over Present U.S. 10 - $\frac{2,813,400 - 2,305,600}{461,650 - 71,700} = 1.30$

Line 2 over Present U.S. 10 - $\frac{2,813,400 - 2,297,700}{579,890 - 71,700} = 1.01$

Line 2 over Line 1 - $\frac{2,305,600 - 2,297,700}{579,890 - 461,650} = 0.07$

TABLE 11

COST ESTIMATE

ROUTE 1

Sta. 0 + 00 to Sta. 450 + 00

Item	Unit	Quantity	Unit Price	Cost
Clearing and Grubbing	Acres	121	$500	$60,500
Unclassified Excavation	Cu.Yds.	1,397,640	0.626	875,220
Borrow Excavation	Cu.Yds.	500,000	0.40	200,000
Watering	M. Gals.	37,940	1.10	41,730
Rolling		4,750	7.80	37,050
Overhaul	Yd.Mi.	196,420	0.15	29,460
Rip Rap	Cu.Yds.	800	5.00	4,000
4-Lane Pav't. 46' Med.	Miles	4.73	103,200	488,140
4-Lane Pav't, 8' Med.	Miles	3.79	96,840	367,020
Ramps	Miles			
Cross Roads - Paved	Miles			
Frontage Roads - Gravel	Miles	6.0	6,240	37,440
Guardrail (Double)	Lin.Ft.	20,000	5.00	100,000
Guardrail	Lin.Ft.	35,000	3.00	105,000
Minor Drainage	Miles	8.52	7,500	63,900
Major Drainage				26,850
Structures				203,400
Lighting and Signing				
Utilities				31,100
Traffic Maintenance				45,000
R.O.W. Fence	Rods	5,450	5.44	29,650
		CONSTRUCTION COST		$2,745,460
Right-of-Way				106,000
Engineering and Contingencies (15% of Construction Cost)				411,820
		TOTAL ESTIMATED COST		$3,263,280

STAGES OF CONSTRUCTION

1.	Clearing and Grubbing, Excavation, Drainage, Utilities and Structures	$1,618,210
2.	Surfacing, Guardrail, Signing and Lighting	1,127,250
		$2,745,460

TABLE 12

COST ESTIMATE

ROUTE 1

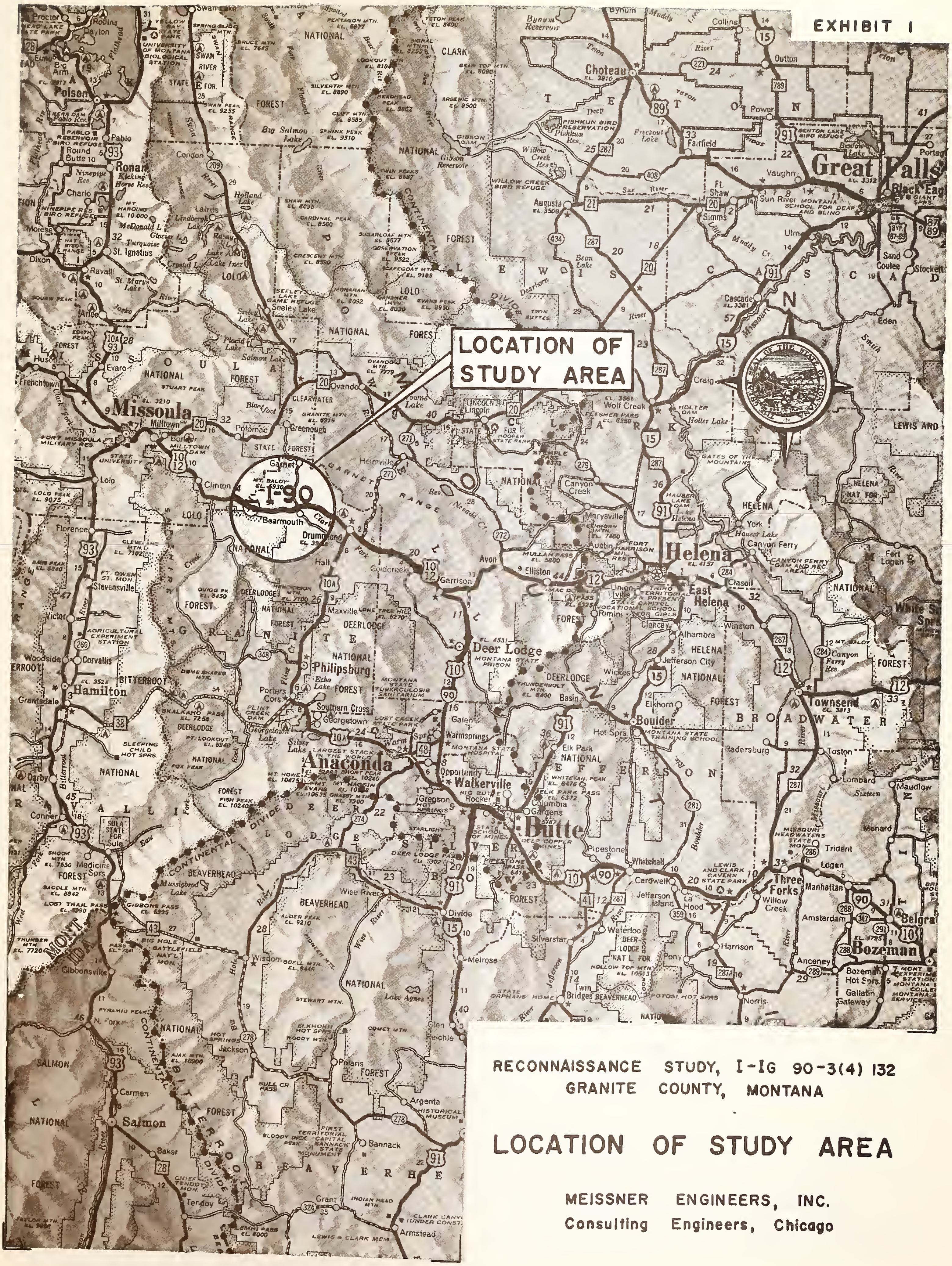
Sta. 450 + 00 to Sta. 894 + 50

Item	Unit	Quantity	Unit Price	Cost
Clearing and Grubbing	Acres	124	$500	$62,000
Unclassified Excavation	Cu.Yds.	1,791,460	0.690	1,235,790
Borrow Excavation	Cu.Yds.	909,000	0.40	363,600
Watering	M.Gals.	54,144	1.10	59,560
Rolling		6,760	7.80	52,730
Overhaul	Yd.Mi.	527,110	0.15	79,070
Rip Rap	Cu.Yds.	4,200	5.00	21,000
4-Lane Pav't., 46' Med.	Miles	2.17	103,200	223,940
4-Lane Pav't., 8' Med.	Miles	6.18	96,840	598,470
Ramps	Miles	2.0	32,030	64,060
Cross Roads - Paved	Miles	0.2	29,790	5,960
Frontage Roads - Gravel	Miles	2.5	6,240	15,600
Guardrail (Double)	Lin.Ft.	32,640	5.00	163,200
Guardrail	Lin.Ft.	36,000	3.00	108,000
Minor Drainage	Miles	8.35	7,500	62,630
Major Drainage				53,000
Structures				468,190
Lighting and Signing				120,000
Utilities				
Traffic Maintenance				50,000
R.O.W. Fence	Rods	5,350	5.44	29,100
			CONSTRUCTION COST	$3,835,900
Right-of-Way				106,000
Engineering and Contingencies (15% of Construction Cost)				575,390
			TOTAL ESTIMATED COST	$4,517,290

STAGES OF CONSTRUCTION

1. Clearing and Grubbing, Excavation, Drainage, Utilities, and Structures	$2,507,570
2. Surfacing, Guardrail, Signing and Lighting	1,328,330
	$3,835,900

EXHIBIT 1



RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

LOCATION OF STUDY AREA

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

EXHIBIT 2

LEGEND

- Preferred Route 1, See Exhibits 5 to 11
- Preferred Route 2, See Exhibits 12 to 18
- Other Alternate Routes Studied, See Text
- ○ Interchange

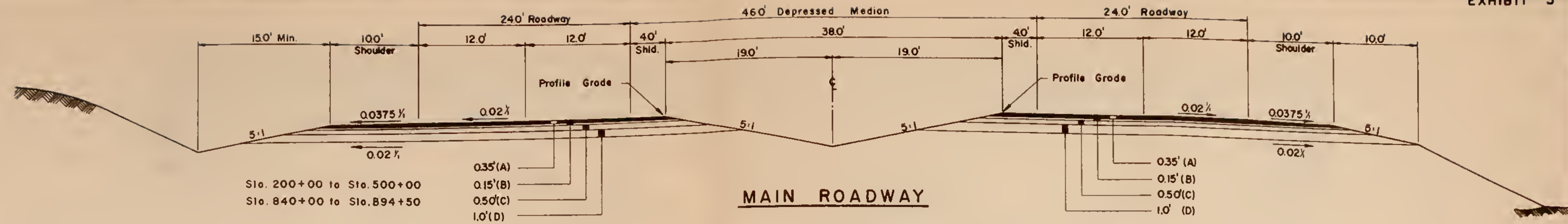
SCALE

1 MILE ½ 0 1 2 MILES

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG-90-3(4) 132
GRANITE COUNTY, MONTANA

ALTERNATE ROUTES STUDIED



MAIN ROADWAY

NOTES

Standard Rounding Required On All Cut Slopes.

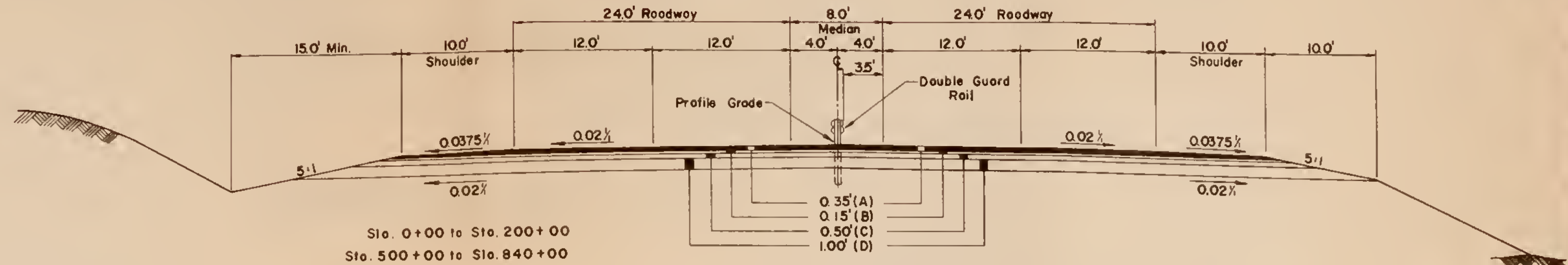
Cut Back Slopes And Fill Side Slopes

Depth	Slopes
0'- 5'	5 : 1
5'-10'	4 : 1
10'-15'	3 : 1
over 15'	2 : 1

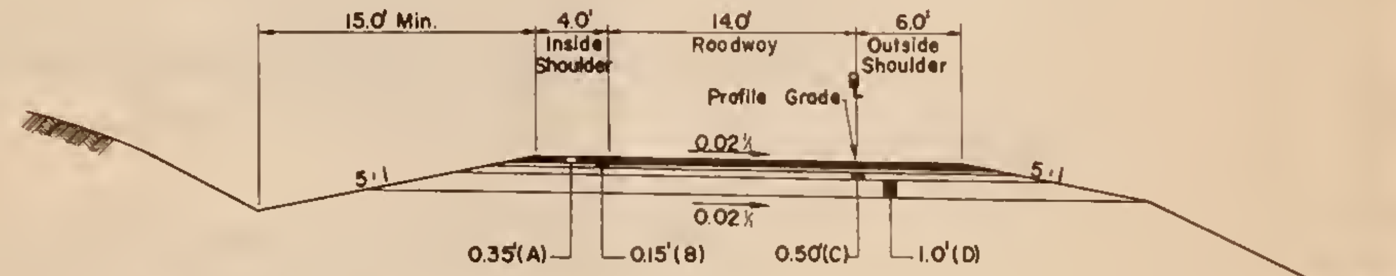
Superelevation On Curves Required As Per A.A.S.H.O. Standards Maximum 0.08'/Ft.

Prime Coat Required For Full Width Of All Bituminous Surfacing.

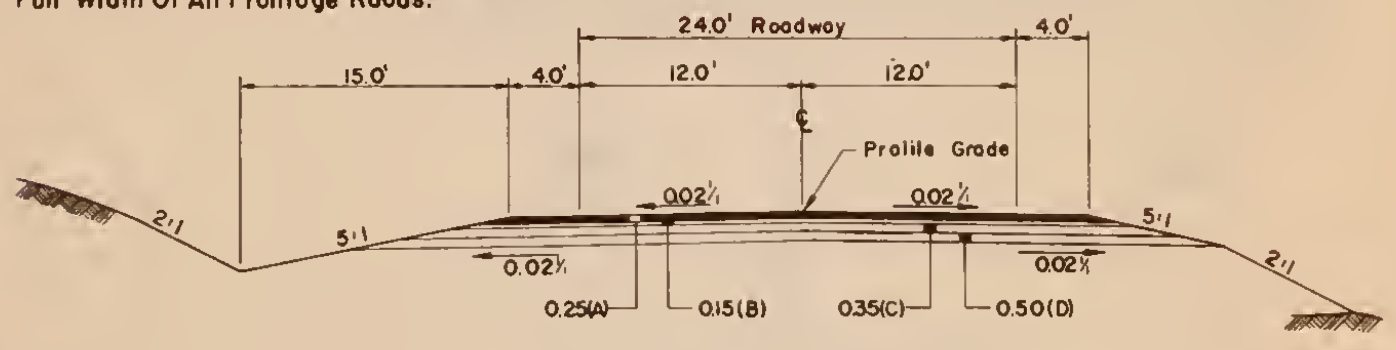
Prime, Seal, and Cover Aggregate Required For Full Width Of All Frontage Roads.



MAIN ROADWAY



RAMPS



CROSS ROADS

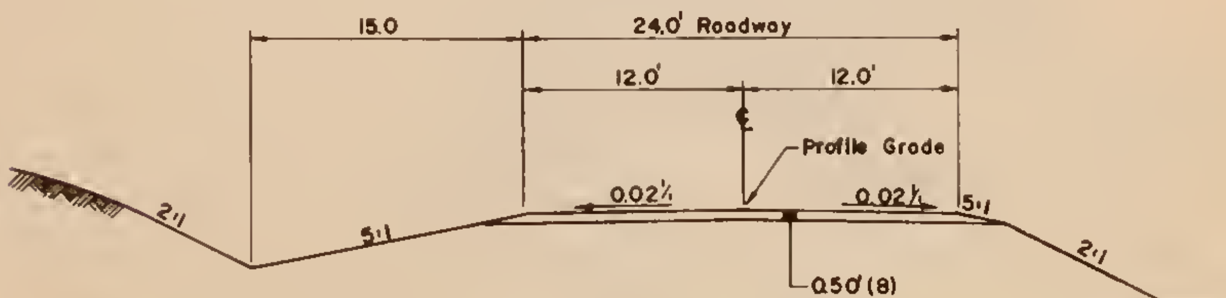
LEGEND

A = Compacted Plant Mix Bituminous Surfacing, Type 3, (2 Course) Prime Coat (No Seal Or Cover)

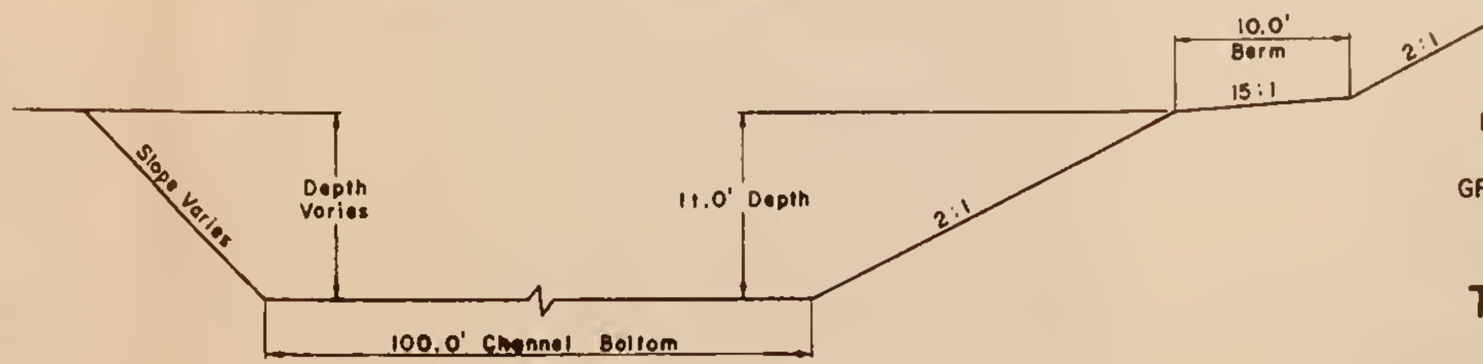
B = Compacted Crushed Top Surfacing, Type "A" Grade 2

C = Compacted Crushed Base Surfacing, Grade 5

D = Compacted Crushed Base Surfacing, Grade 2



CROSS ROADS AND FRONTAGE ROADS



CHANNEL CHANGE

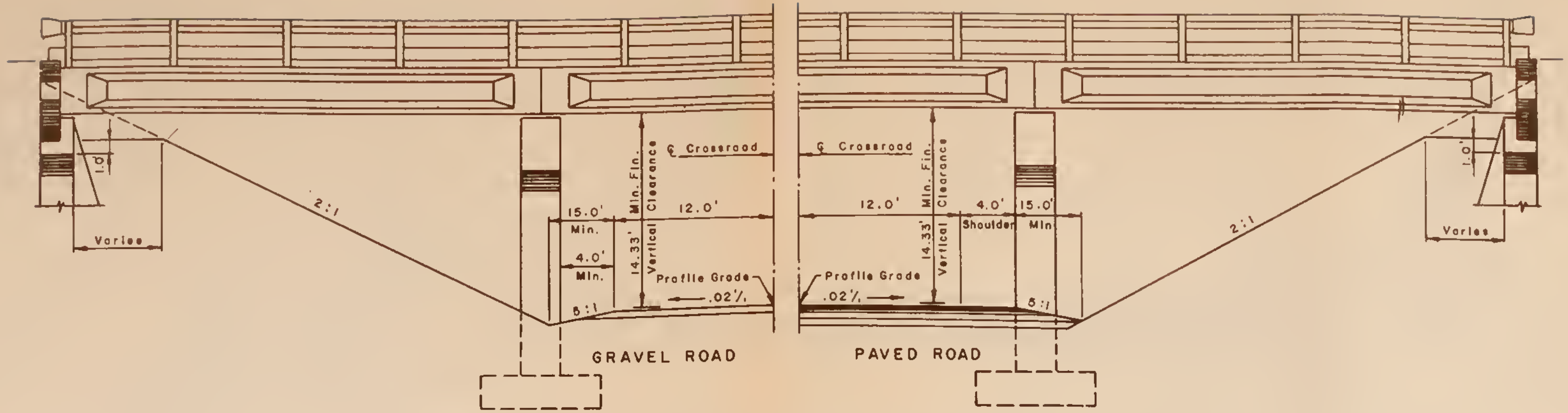
Scale

10 FEET 0 10 FEET

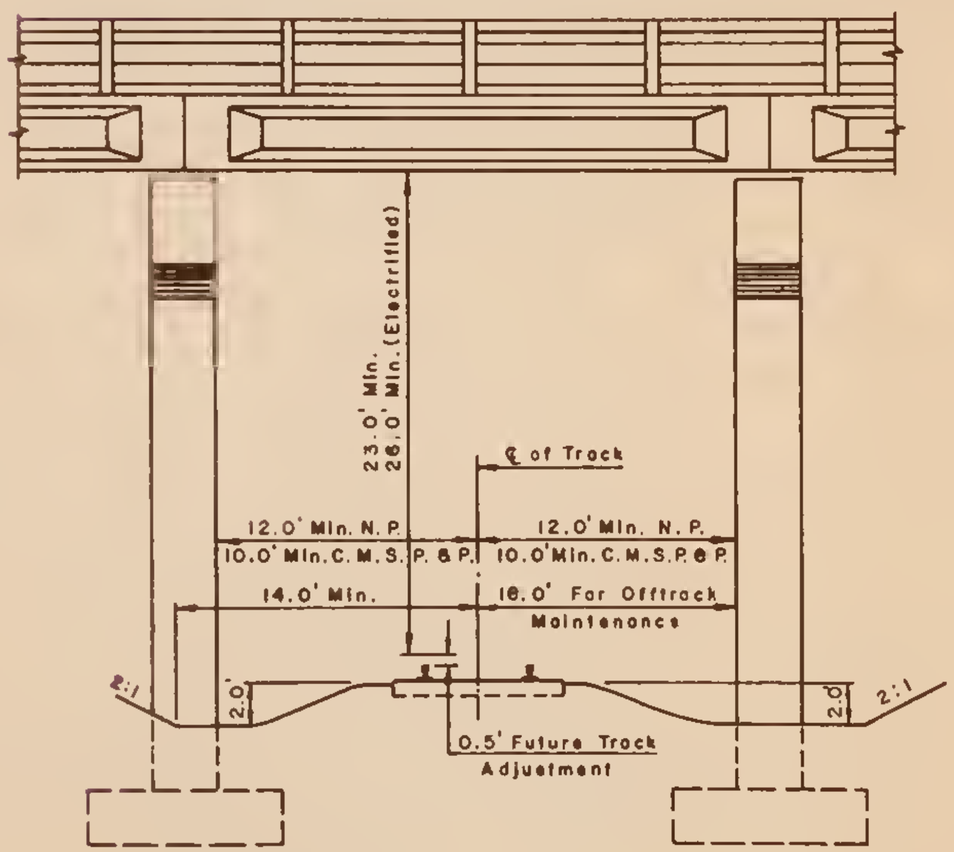
RECONNAISSANCE STUDY,
I-IG-90-3(4) 132
GRANITE COUNTY, MONTANA

ROADWAY TYPICAL SECTIONS

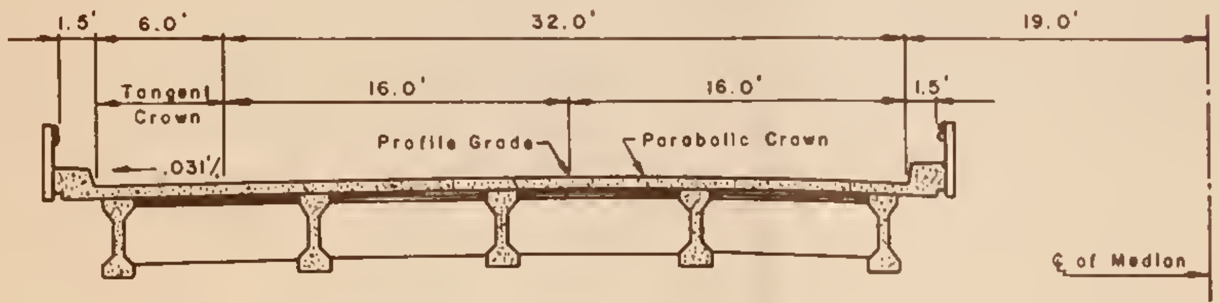
MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago



HALF SECTIONS - CROSSROAD UNDERPASS



TYPICAL SECTION - RAILROAD UNDERPASS



ROADWAY SECTION - INTERSTATE OVERPASS

SCALE

10 Feet 0 10 Feet

Notes

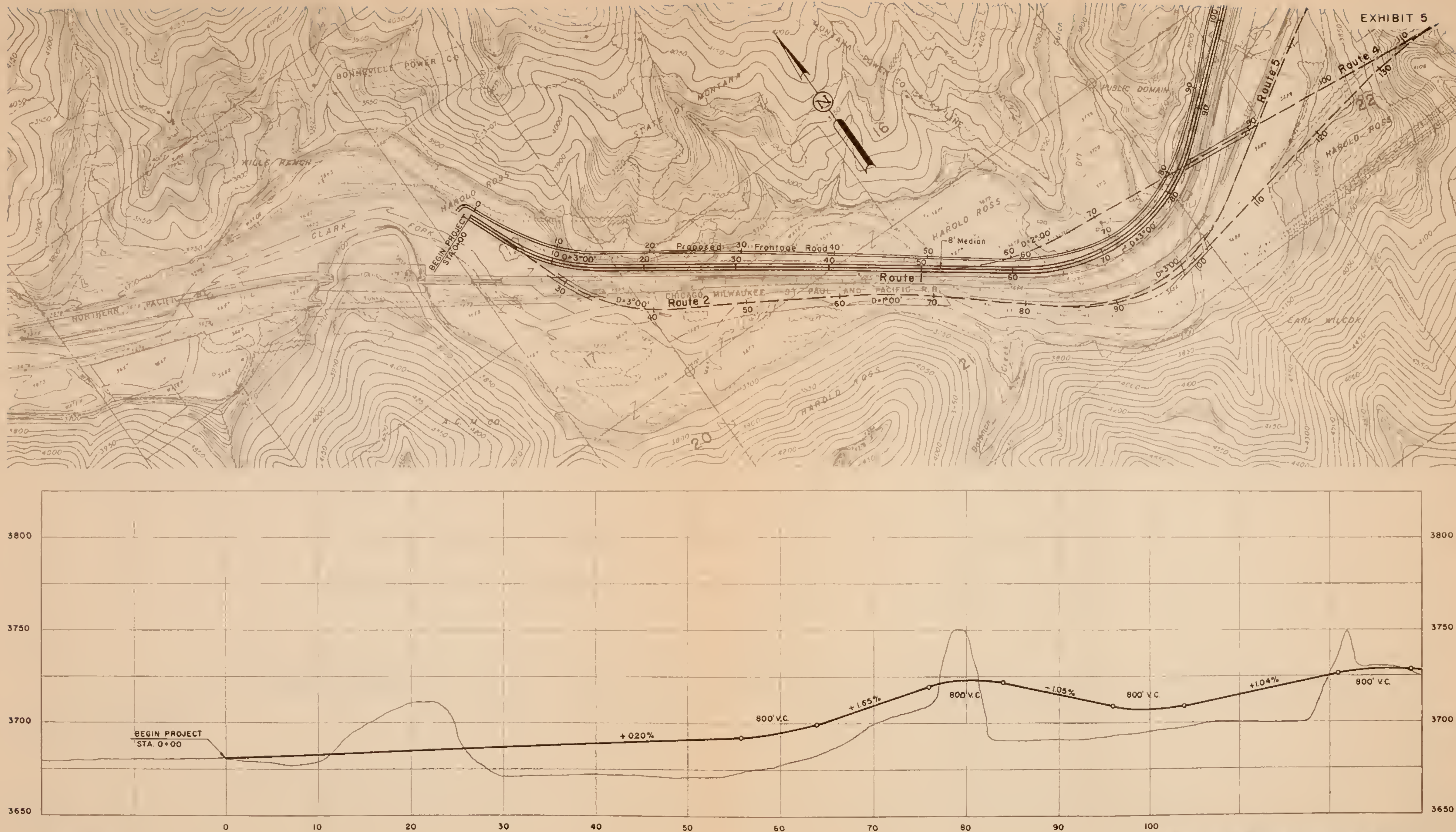
1. The bridge beam depths, spacings and types shown are for illustrative purposes only.
2. For Interstate overpass structures having a rail length of 250' or less between abutments, use shoulder and curb widths as shown.
3. For Interstate overpass structures having a rail length over 250' between abutments use 2' shoulder width and 1.8' curb width.

RECONNAISSANCE STUDY,
I-IG-90-3(4)132
GRANITE COUNTY, MONTANA

BRIDGE
TYPICAL SECTIONS

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

EXHIBIT 5



SCALE

HORIZONTAL 0 500 1000 FEET

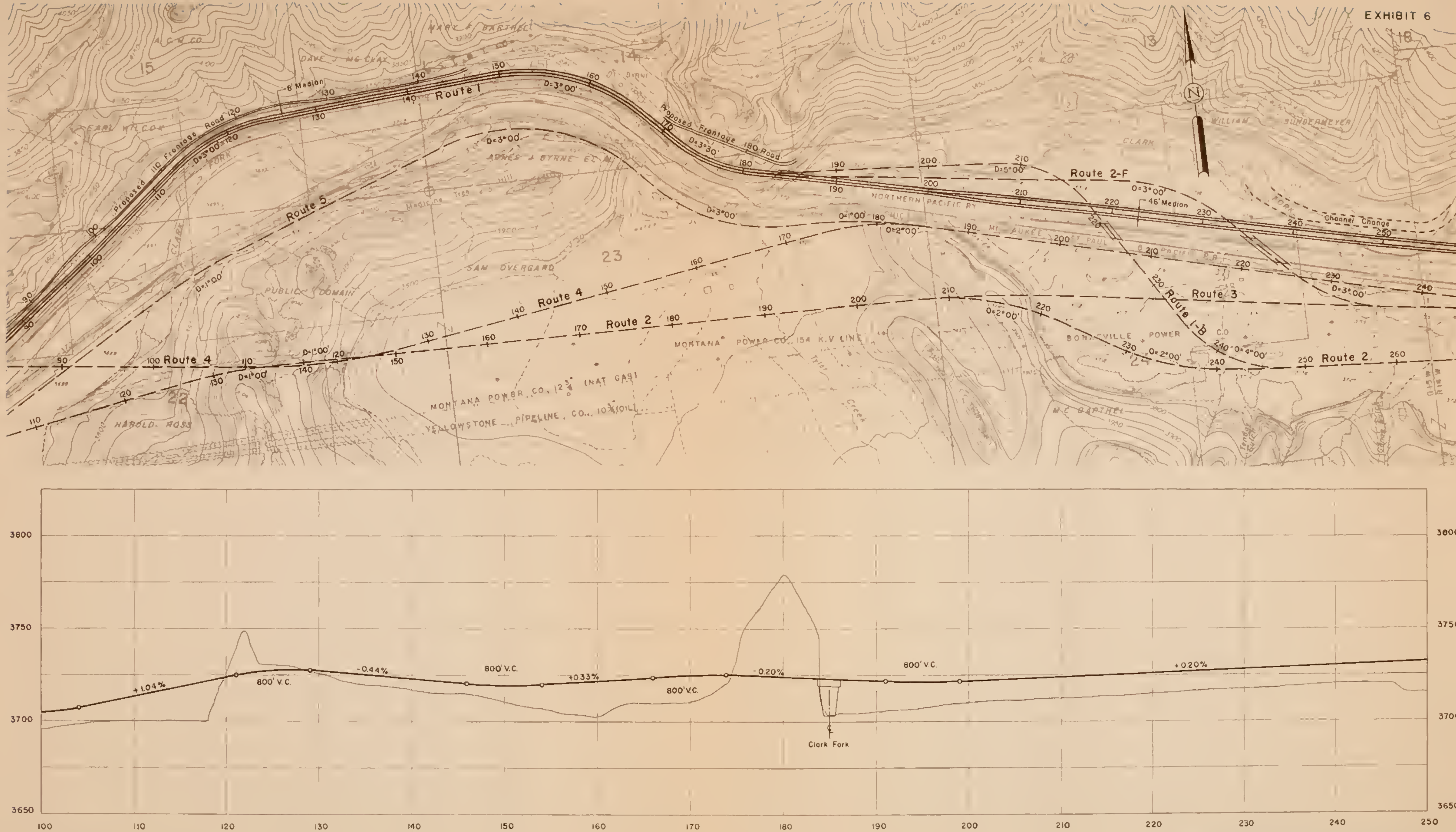
VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 1
STA. 0+00 TO STA. 100+00

EXHIBIT 6



SCALE

HORIZONTAL 0 500 1000 FEET

VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.

Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132

GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE I

STA. 100+00 TO STA. 250+00

EXHIBIT 7

SCALE

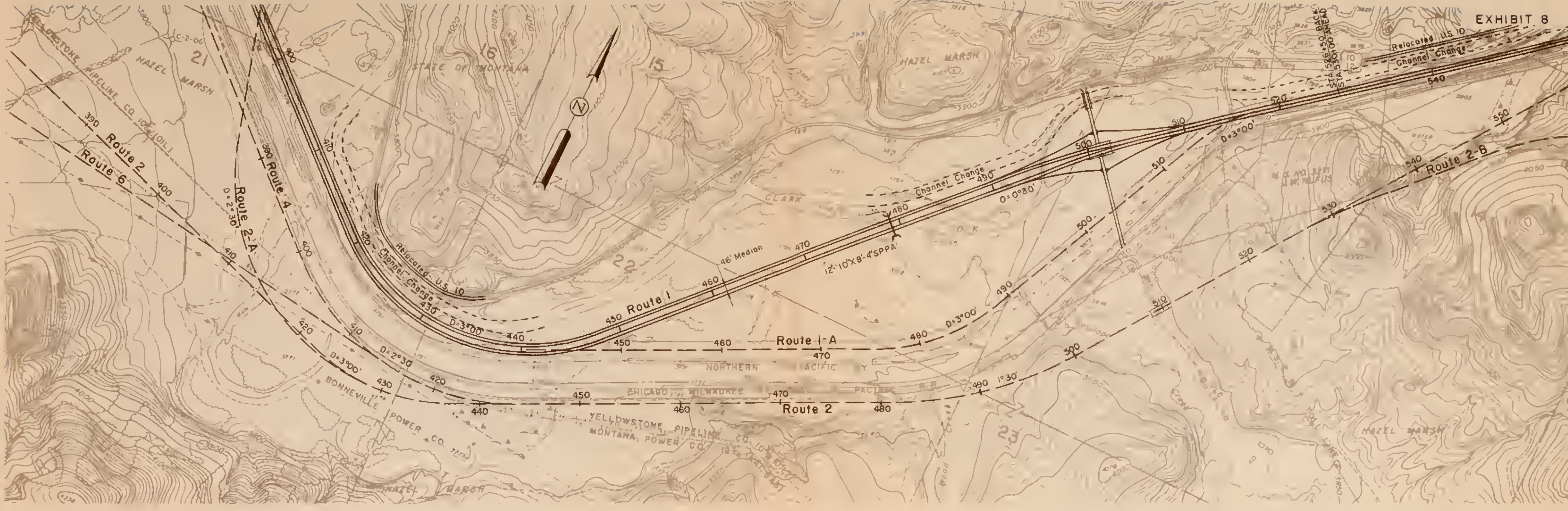
HORIZONTAL 0 500 1000 FEET

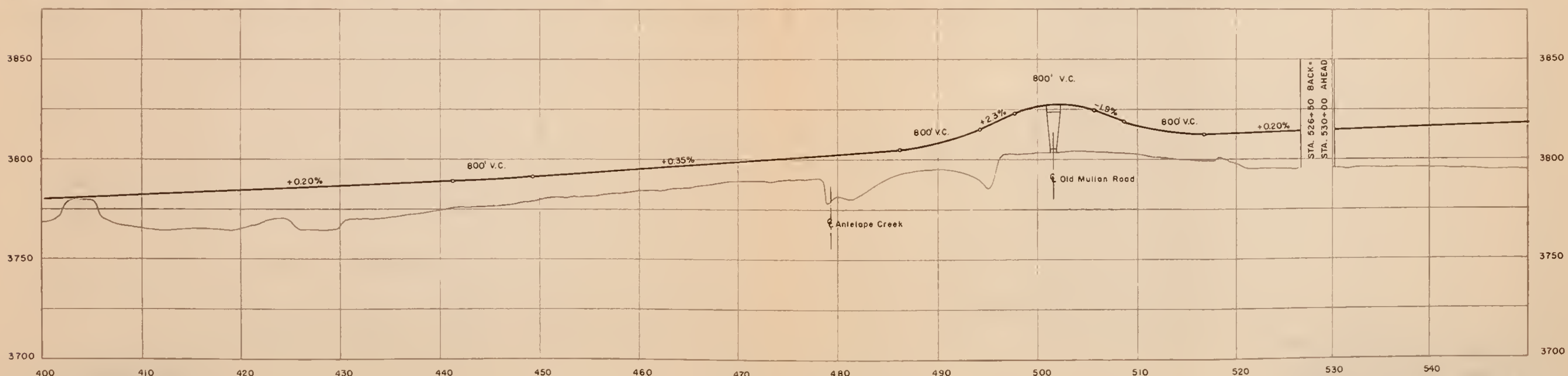
VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE I
STA. 250+00 TO STA. 400+00





SCALE

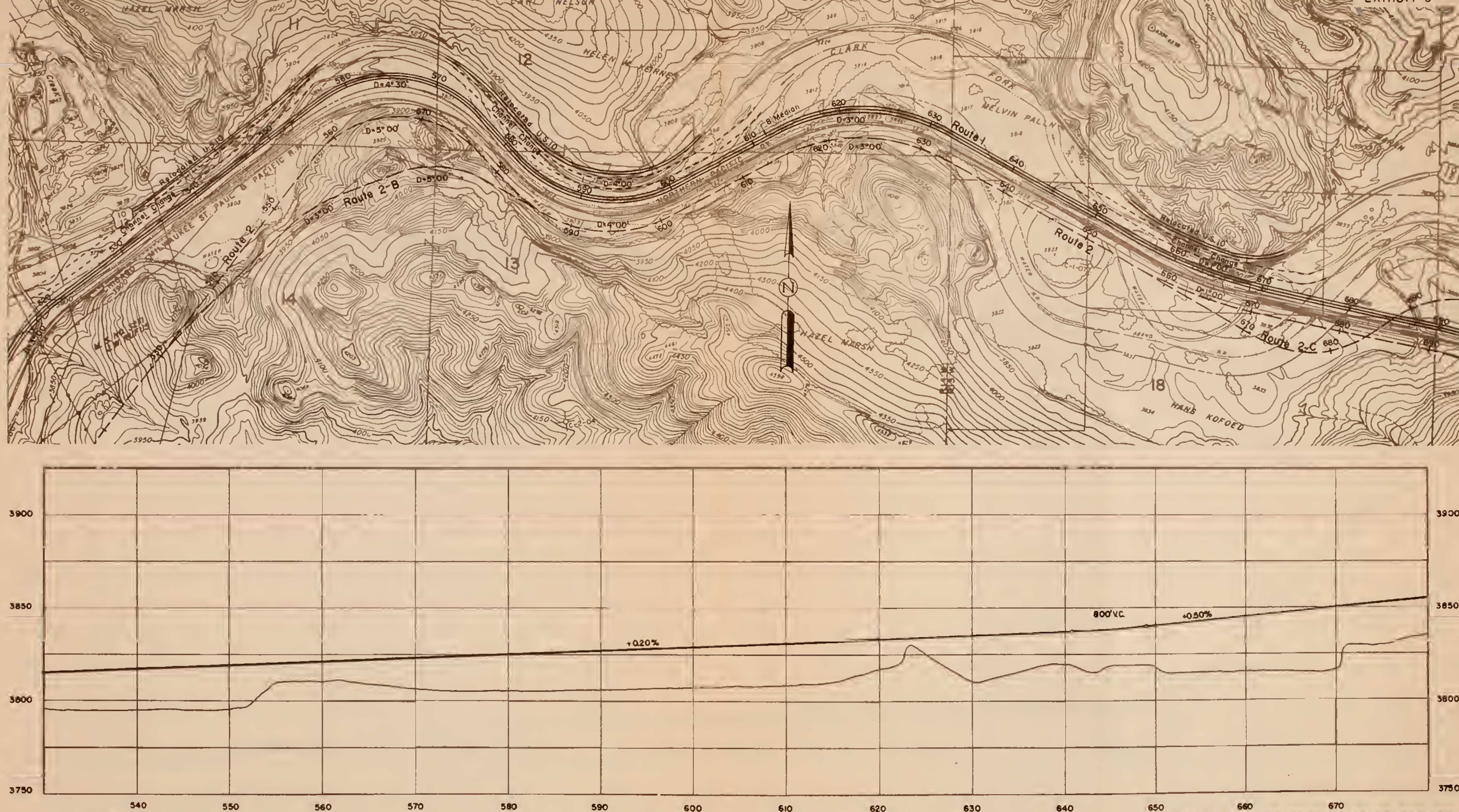
HORIZONTAL 0 500 1000 FEET

VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 1
STA. 400+00 TO STA. 540+00



SCALE

HORIZONTAL 0 500 1000 FEET

VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 1
STA. 540+00 TO STA. 670+00

EXHIBIT 10

SCALE

HORIZONTAL 0 500 1000 FEET

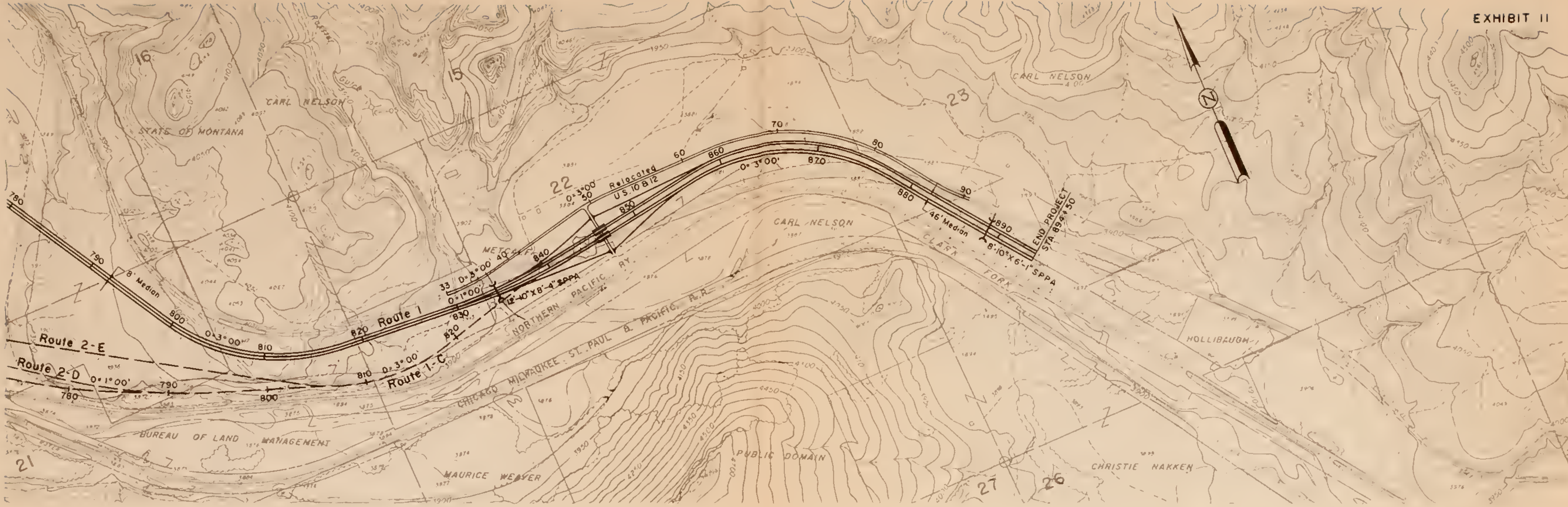
VERTICAL 0 25 50

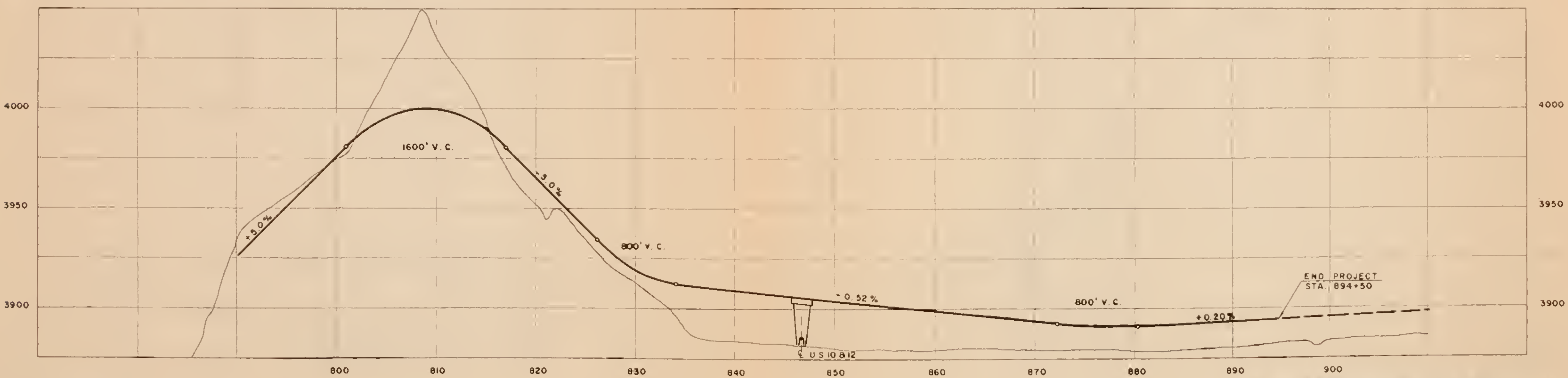
MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 1
STA. 670+00 TO STA. 800+00

EXHIBIT 11





SCALE

HORIZONTAL 0 500 1000 FEET

VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 1
STA. 800+00 TO STA. 894+50

EXHIBIT 12

SCALE

HORIZONTAL 0 500 1000 FEET

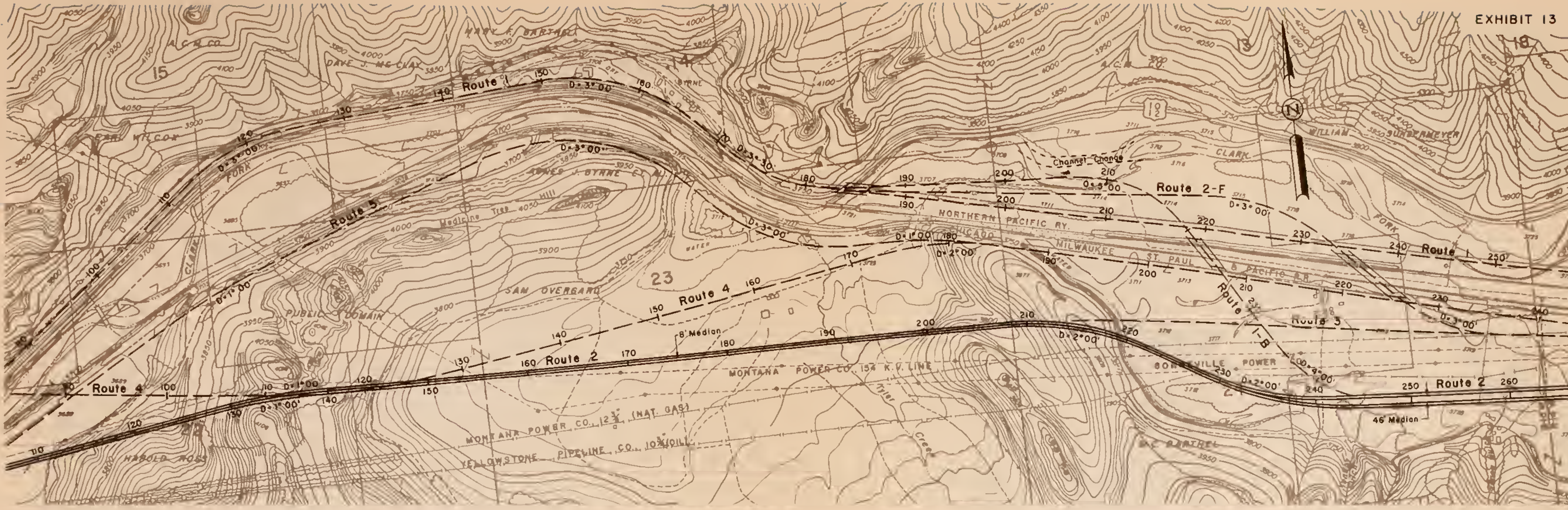
VERTICAL 0 25 50 FEET

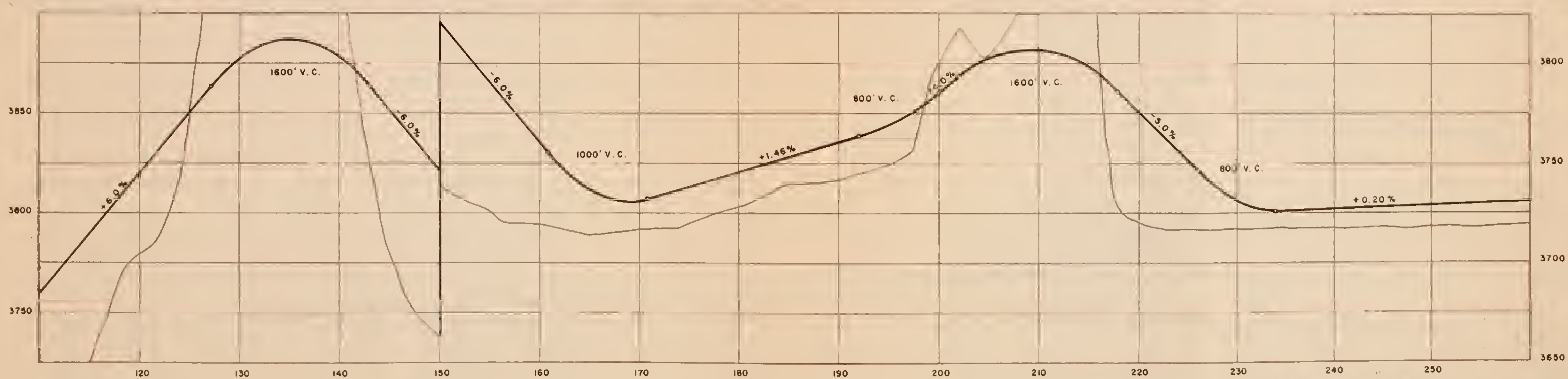
MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE-ROUTE 2
STA. 15+00 TO STA. 120+00

EXHIBIT 13





SCALE

HORIZONTAL 0 500 1000 FEET

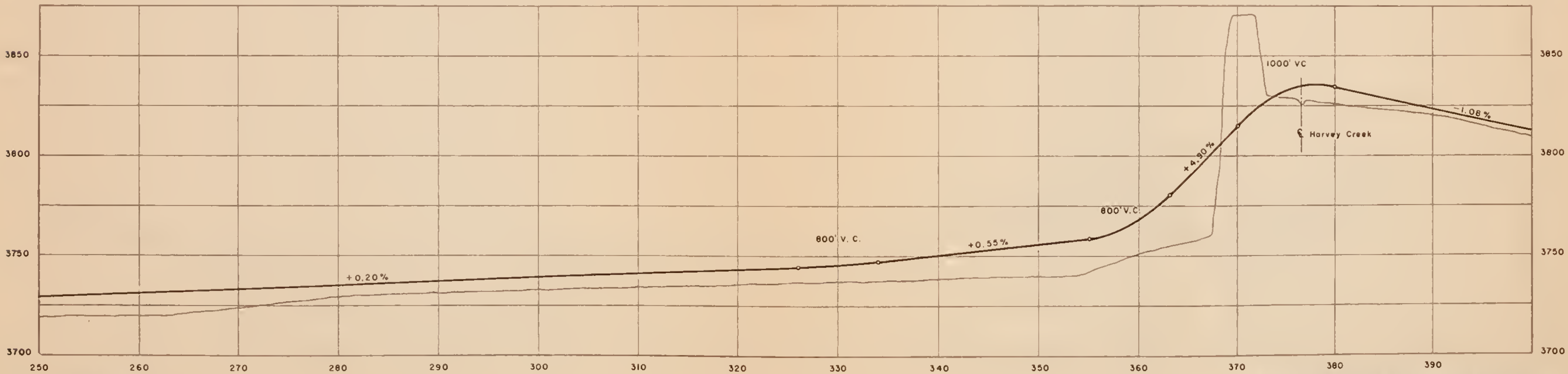
VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 2
STA. 120 + 00 TO STA. 250 + 00

EXHIBIT 14



SCALE

HORIZONTAL 0 500 1000 FEET

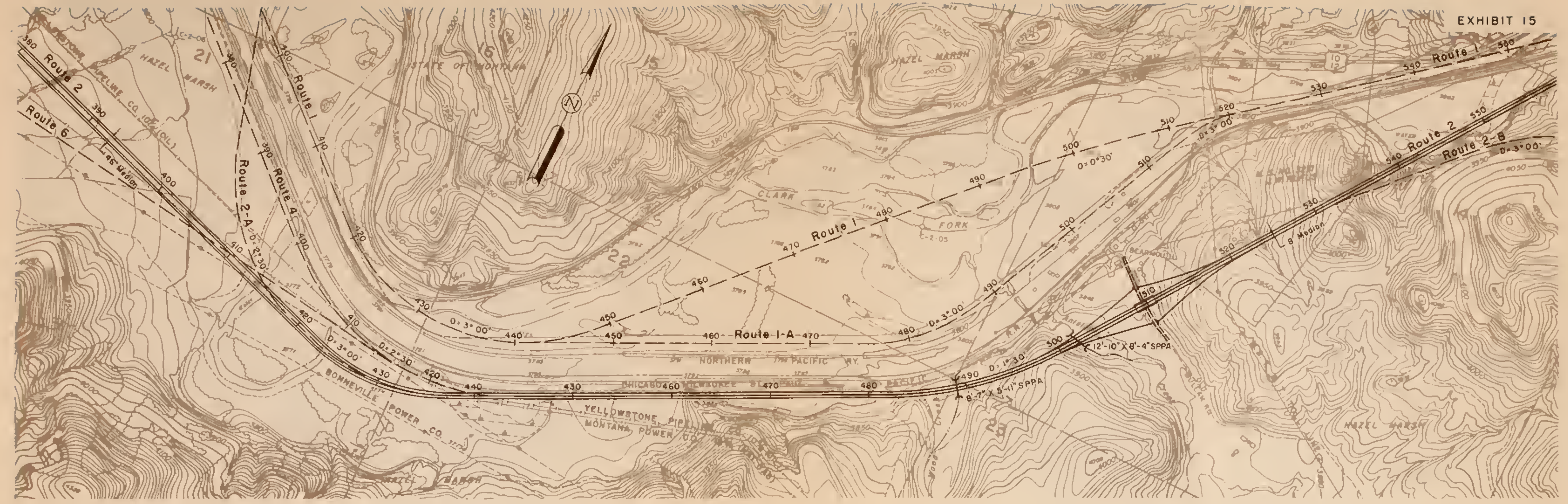
VERTICAL 0 25 50 FEET

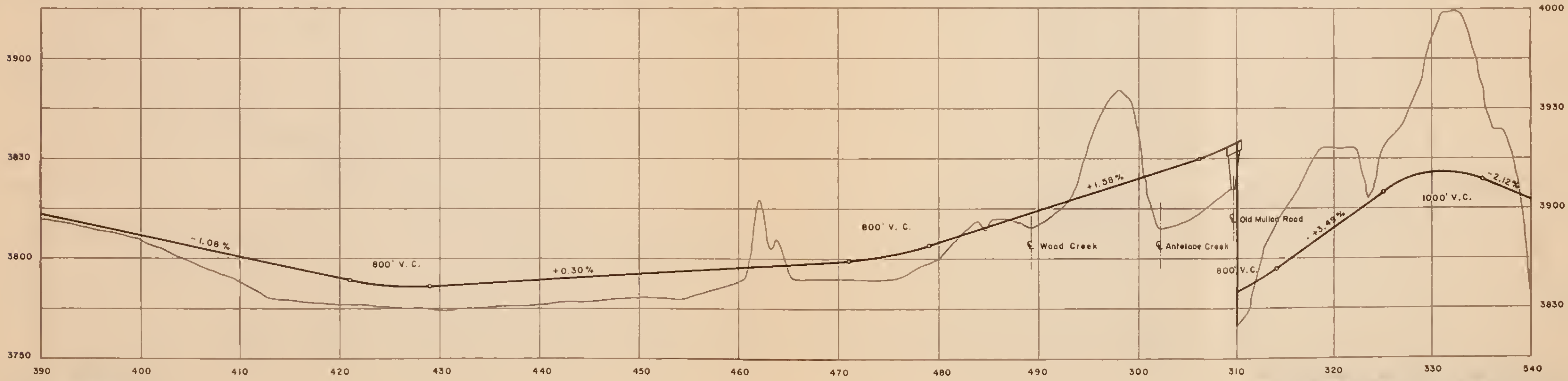
MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 2
STA. 250 + 00 TO STA. 390 + 00

EXHIBIT 15





SCALE

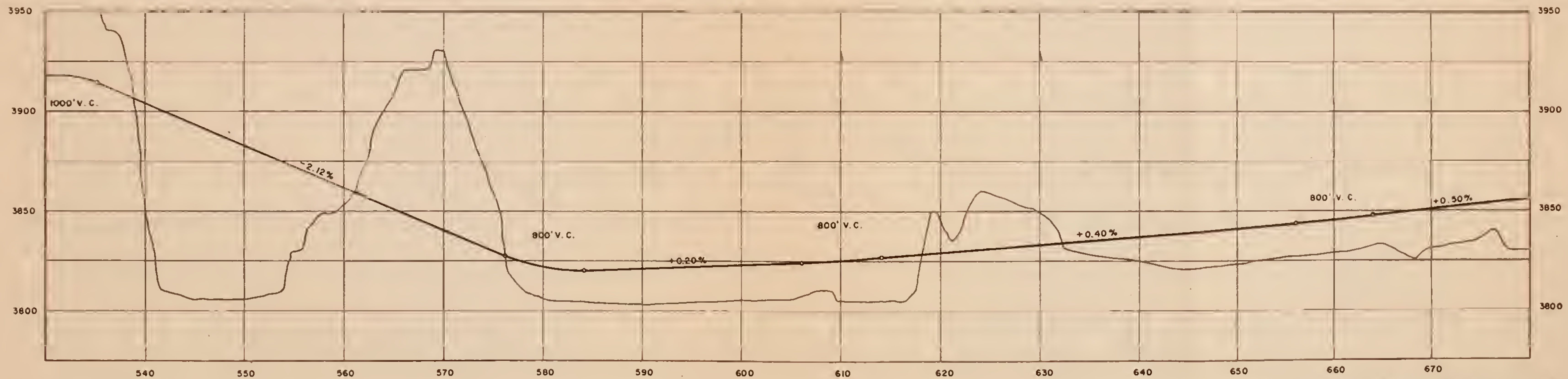
HORIZONTAL 0 500 1000 FEET

VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 2
STA. 390 + 00 TO STA. 540 + 00



SCALE

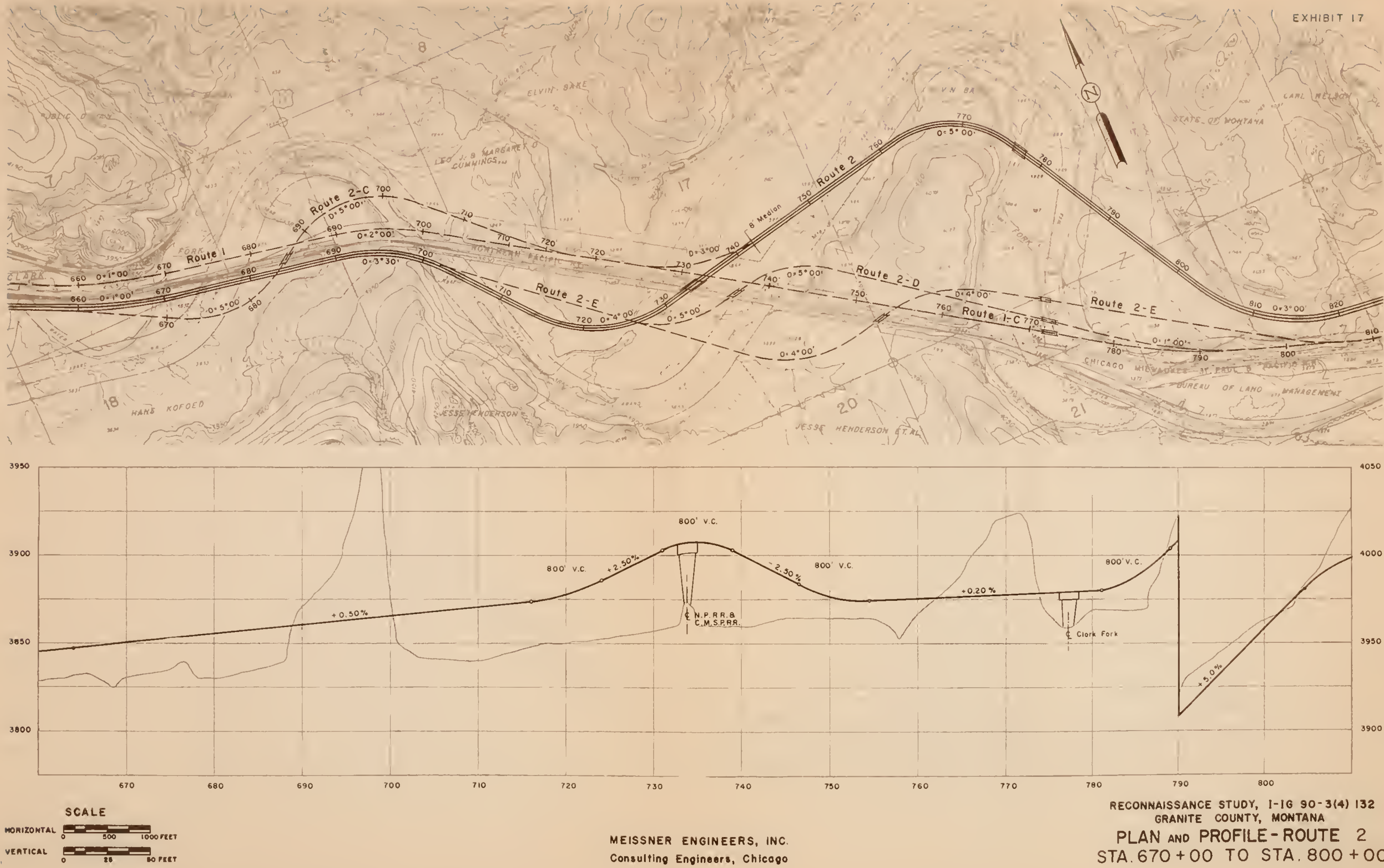
HORIZONTAL 0 500 1000 FEET

VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 2
STA. 540 + 00 TO STA. 670 + 00



MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 2
STA. 670+00 TO STA. 800+00

EXHIBIT 18

SCALE

HORIZONTAL 0 500 1000 FEET

VERTICAL 0 25 50 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

RECONNAISSANCE STUDY, I-IG 90-3(4) 132
GRANITE COUNTY, MONTANA

PLAN AND PROFILE - ROUTE 2
STA. 800+00 TO STA. 897 + 50

EXHIBIT 19

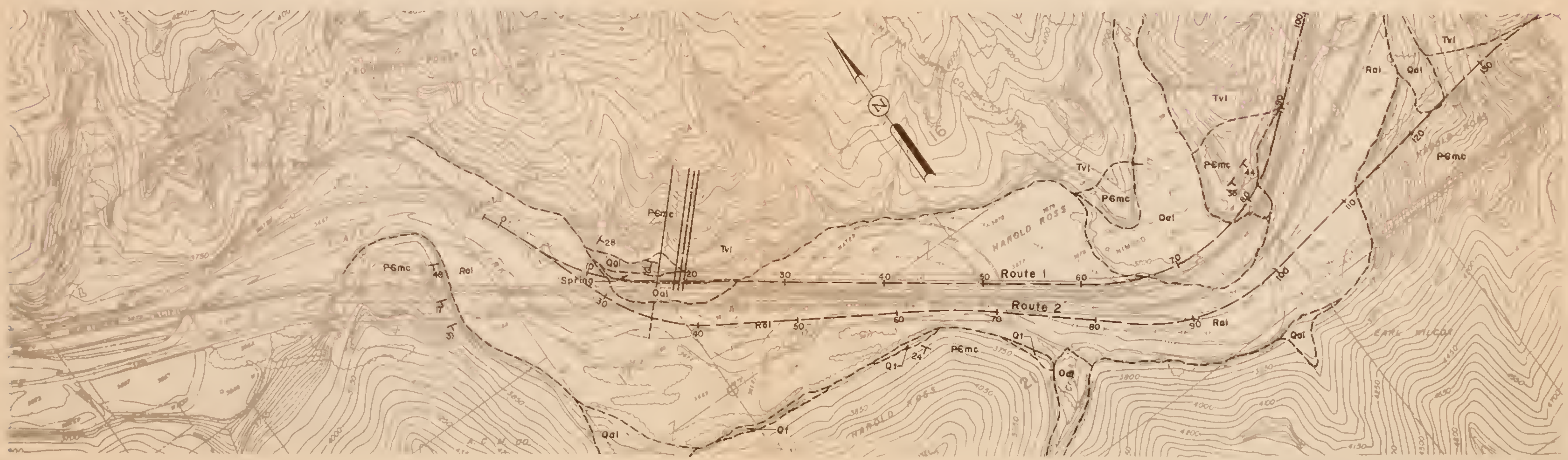
LEGEND

NAME	SYMBOL	DESCRIPTION
River Gravels	Ral	Stream rounded boulders, cobbles, gravel with sand, silt and clay.
Alluvial fans and Terraces	Qal	Stream deposits of rock fragments, angular to rounded, with silt and clay.
Recent Talus Deposits	Qt	Talus piles of fragmentary rock, usually angular, with silt and clay.
Glacial Terrace and morainal deposits	Qg	Glacially derived material in poorly sorted deposits of boulders, cobbles, gravel, sand, silt, and clay.
Glacial Lake Deposits	Qgl	Glacially derived material deposited in lakes, composed of bedded silt with clay and thin gravel layers.
Tuffaceous Sediments	Ts	Water deposited, layered sands, silts, and gravel of volcanic ash and detritus.
Welded Tuff	Tvt	Soft white and pink, cemented volcanic ash.
Rhyolite	Tvr	Soft pink and white volcanic rock.
Olivine Basalt	Tvb	Dark brown to black volcanic rock.
Latite	Tvl	Hard, medium grained, porphyritic volcanic rock.
Andesite	Tva	Hard, dark gray to black, very fine grained volcanic rock.
Agglomerate	Tvag	Cemented cobbles, gravel - volcanic origin.
Colorado group	Kc	Quartzose sandstone, siltstone and shale with calcareous sandstone and some thin limestones. Predominantly gray to black.
Kootenai group	Kkd	Gray, crystalline limestone interbedded with gray, fissile shale.
	Kkc (upper clastic)	Thin, green to light gray sandstone beds, interbedded with thick gray, maroon and green shale and mudstone.

NAME	SYMBOL	DESCRIPTION
Kootenai group	Kkh	Hard, gray, crystalline limestone, interbedded with vari-colored siltstone and shale.
	Kka (basal clastic)	Gray and gray brown sandstone and red siltstone interbedded with maroon and green shale.
Morrison formation	Jm	Gray sandstone interbedded with green-gray sandy shale, argillaceous limestone and dark gray fissile shale.
Ellis group	Jes_2 (Swift)	Calcareous, medium grained sandstone, interbedded with gray shale.
	Jer (Rierdon)	Hard, gray argilliferous limestone interbedded with gray shale and siltstone.
	Jes_1 (Sawtooth)	Dark gray siltstone and shale interbedded with sandstone and thin bedded, gray argillaceous limestone.
Phosphoria formation and Quadrant Quartzite	Pq	Hard, bedded chert and quartzite. May contain some sandstone and siltstone in upper portion.
Amsden formation	Pa	Soft red, red-orange, siltstone and limestone, deposited on a karst topography in the Madison limestone.
Madison limestone	Mm	Gray, dense, hard, cherty limestone. Very massive and resistant to weathering.
Hasmark formation	€h	Gray, crystalline, dolomitic limestone.
McNamara argillite	P€mc	Red and green siltstone and argillite with quartzite.
Bonner quartzite	P€b	Pink and tan, cross-bedded, quartzite, with thin sandy shale beds.
Miller Peak argillite	P€m	Red and green sandy argillites with thin sandy shale and quartzite beds.

MAP SYMBOLS

- 30 Strike and dip.
- 60 Overturned beds; strike and dip.
- 40 Normal fault indicating strike, dip and relative movement (exposed).
- 30 Thrust fault indicating strike, dip (inferred).
- Contact between units of rock or formations.
- Zone of normal faults and/or fractures.
- 30 Overturned syncline showing plunge on axis.



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GRANITE COUNTY, MONTANA
GEOLOGIC EXHIBIT
STA. 0+00 TO STA. 100+00

EXHIBIT 20

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EXHIBIT 21

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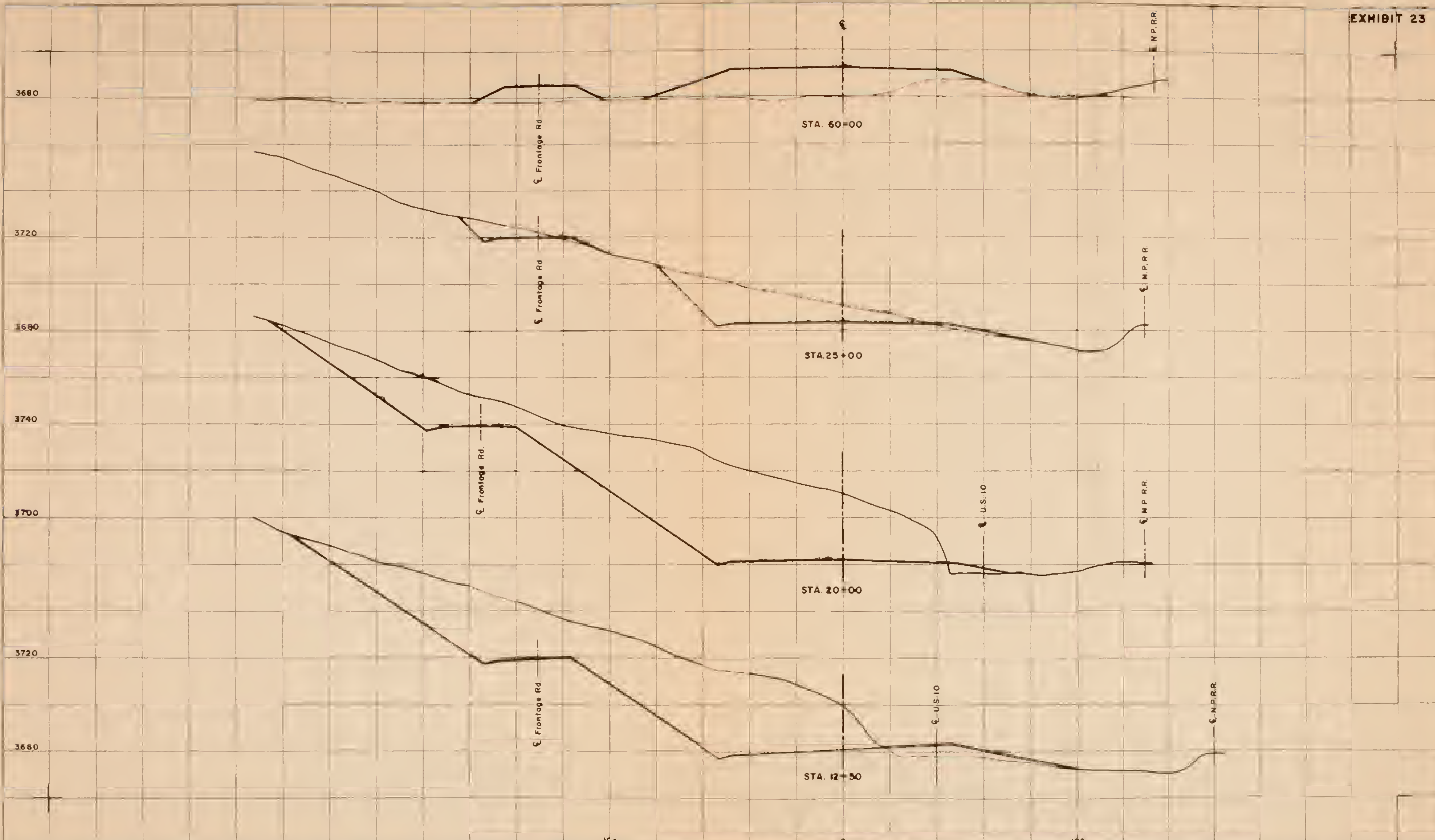

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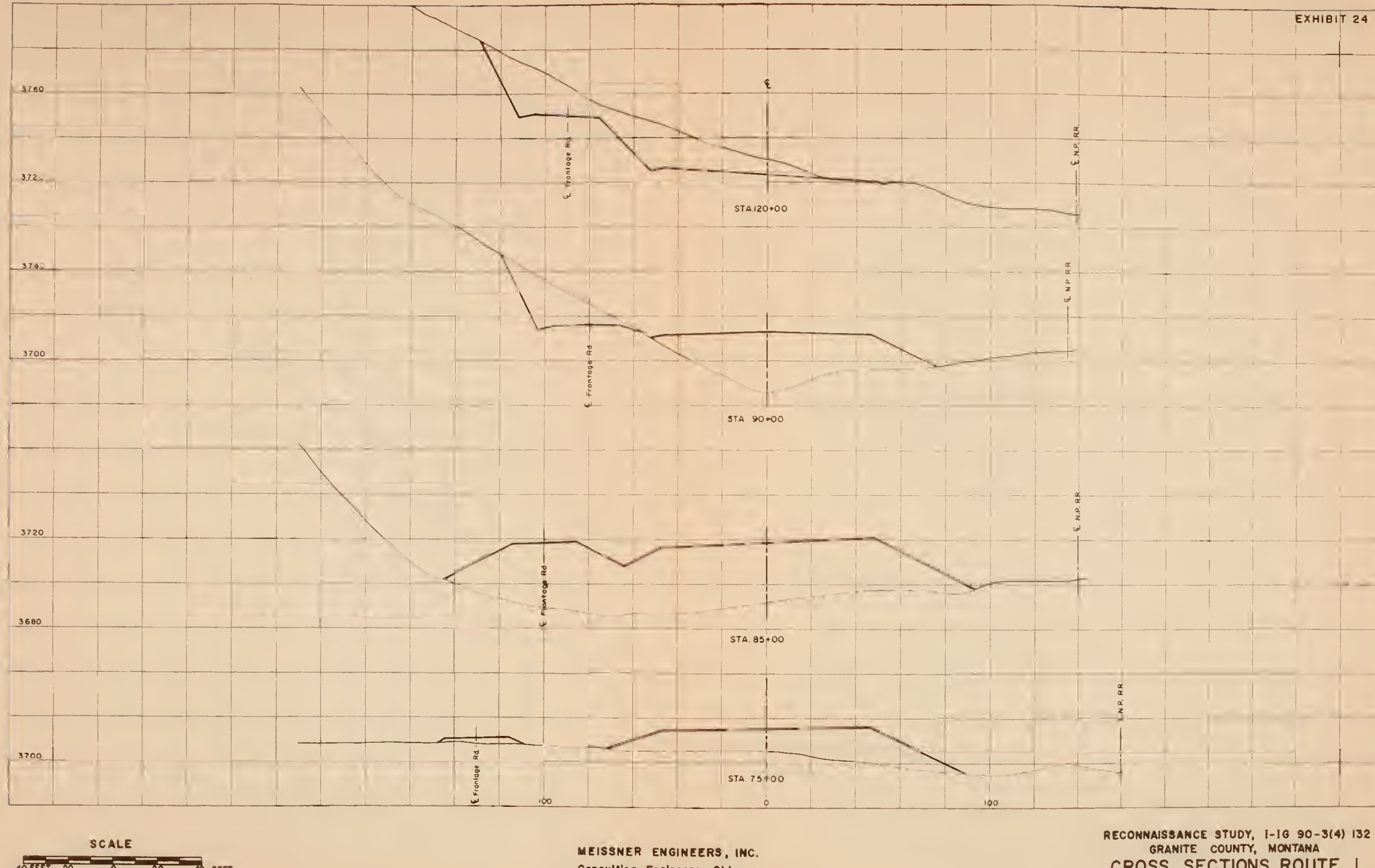

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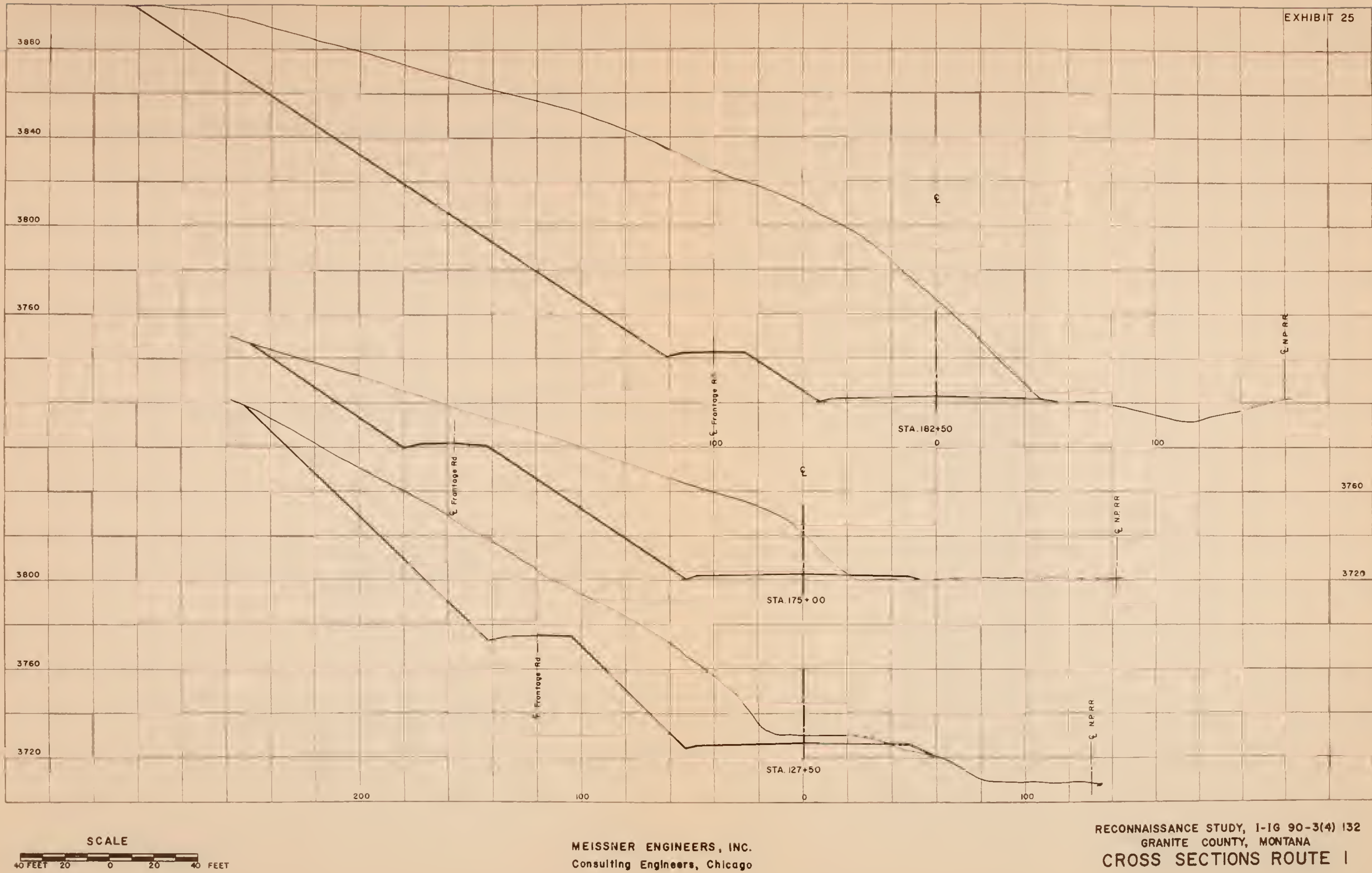

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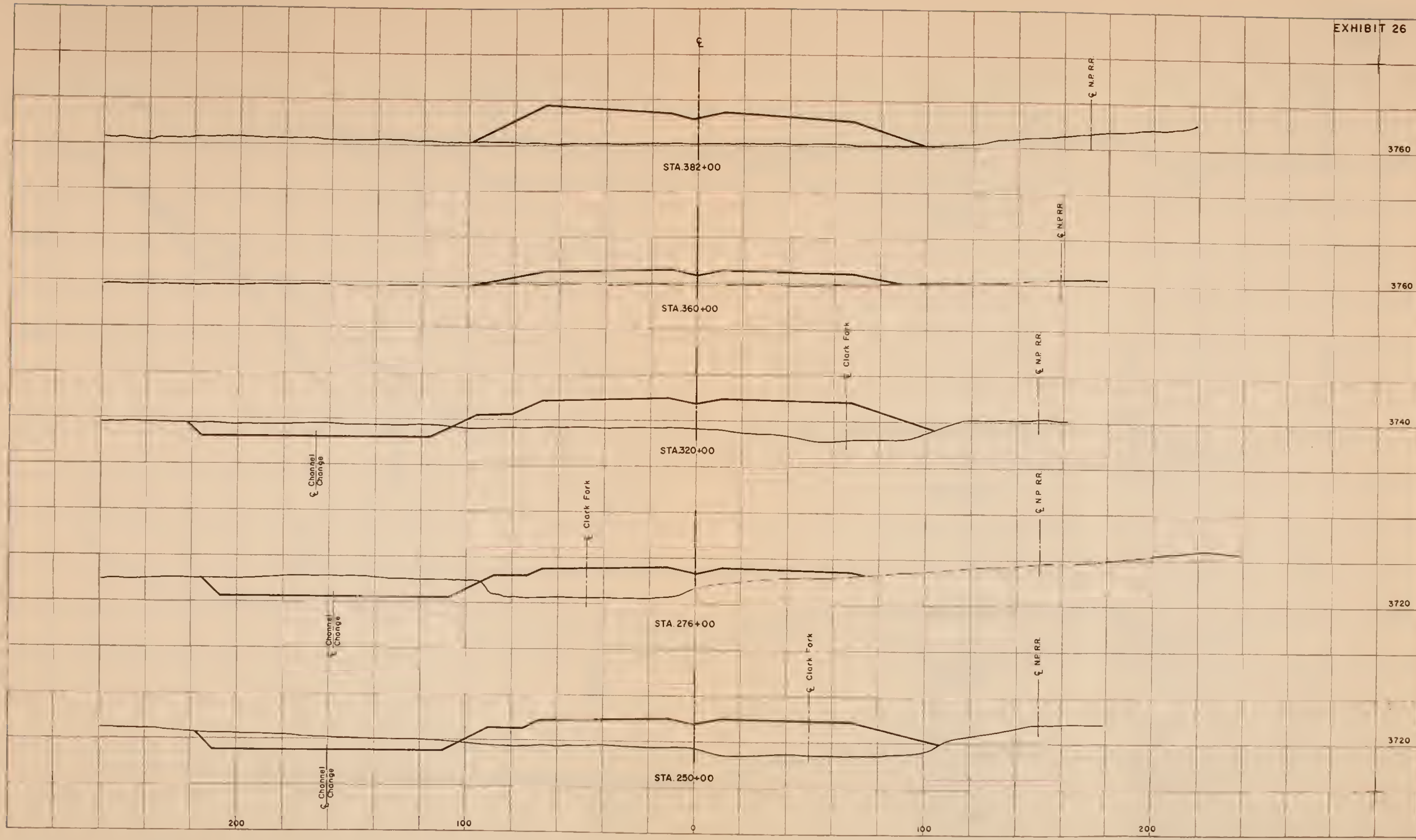

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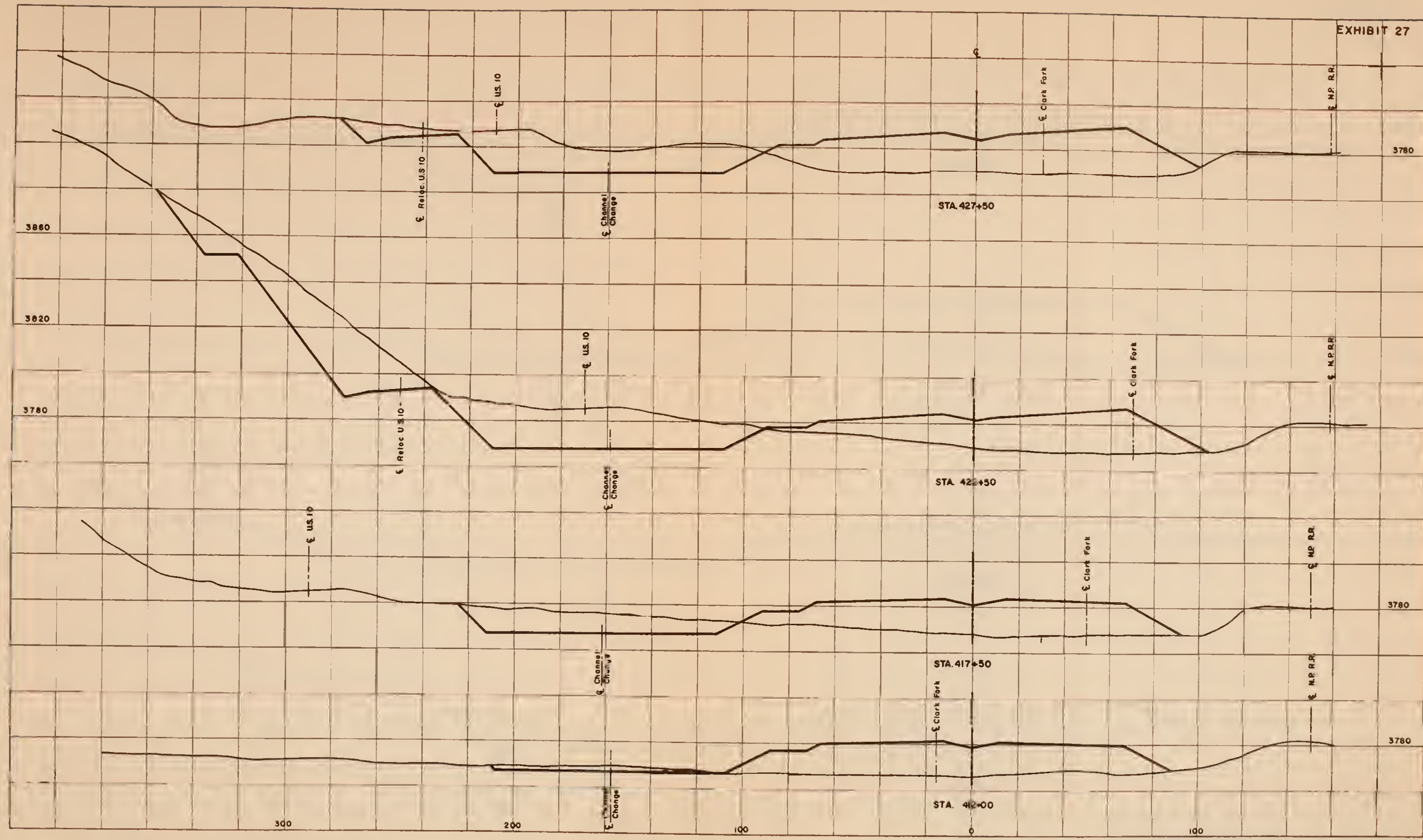

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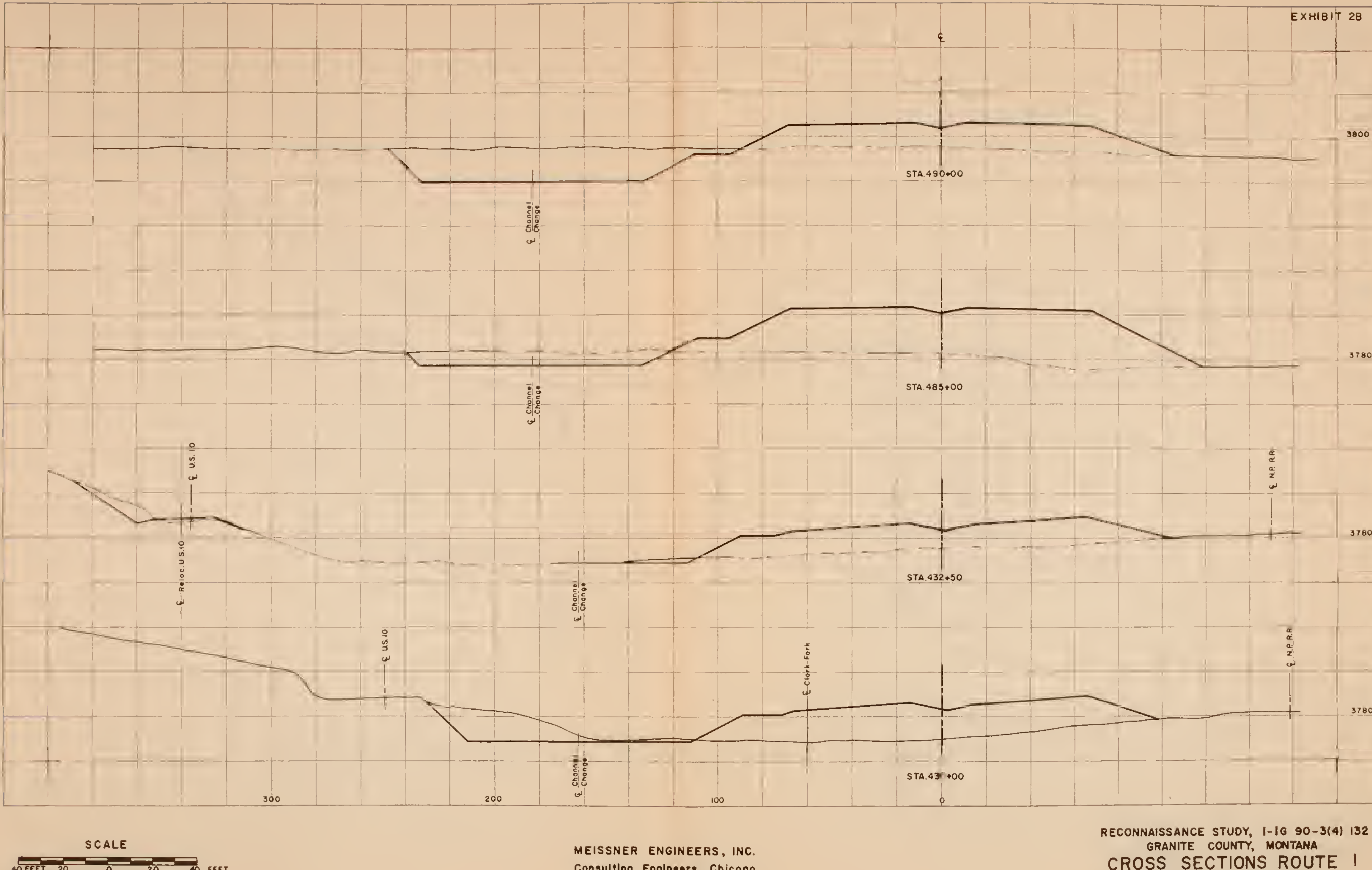

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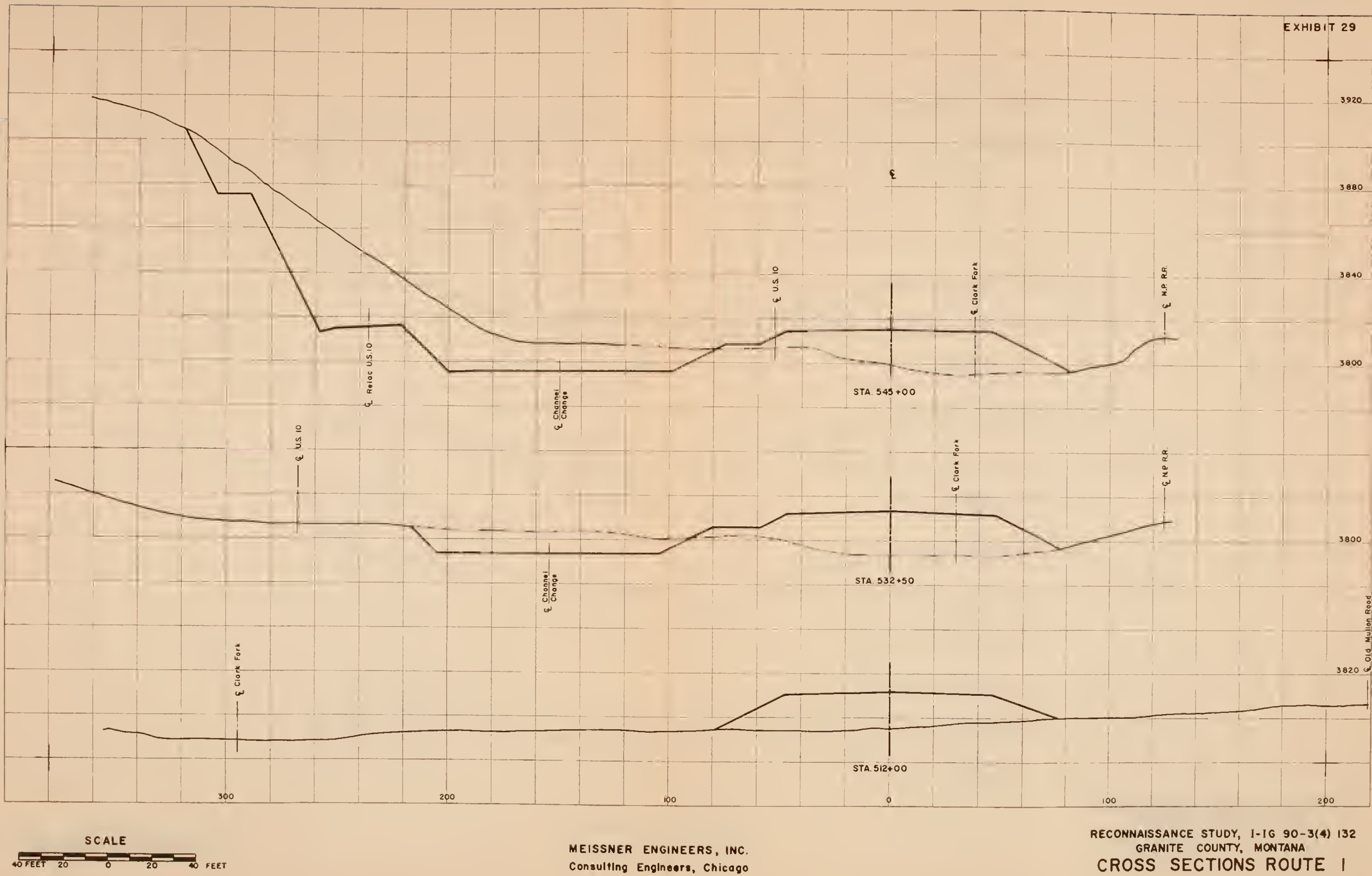

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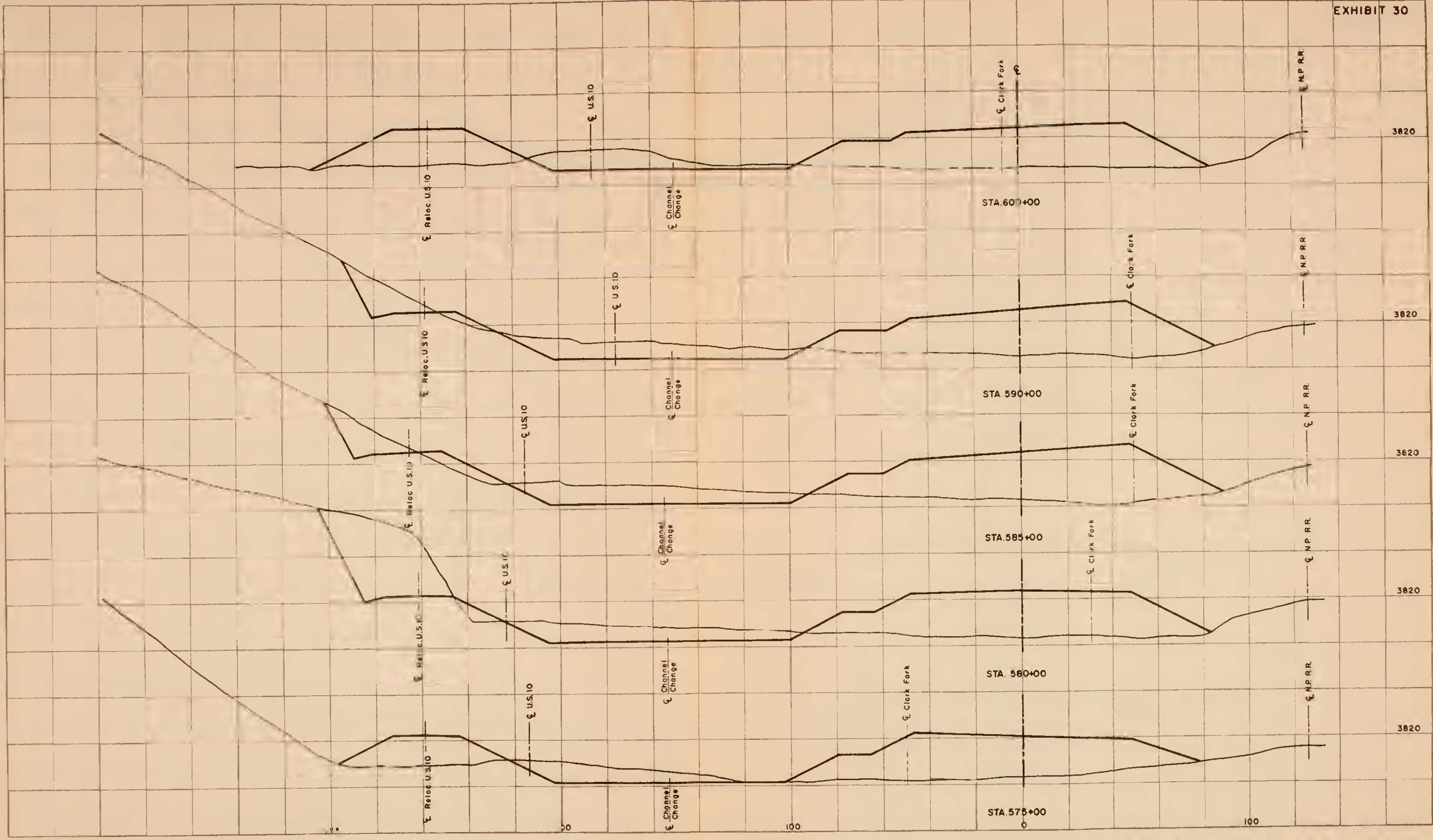

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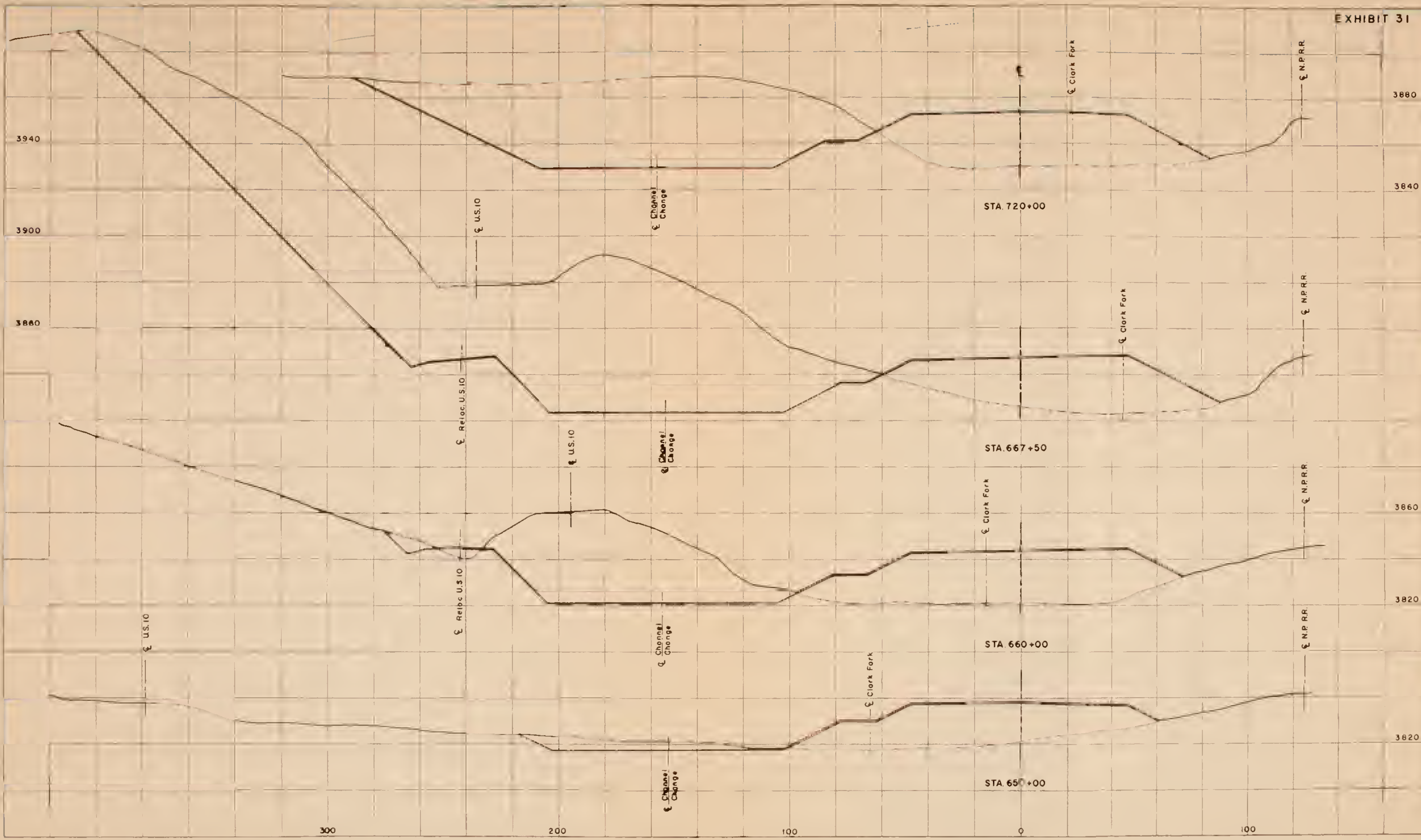

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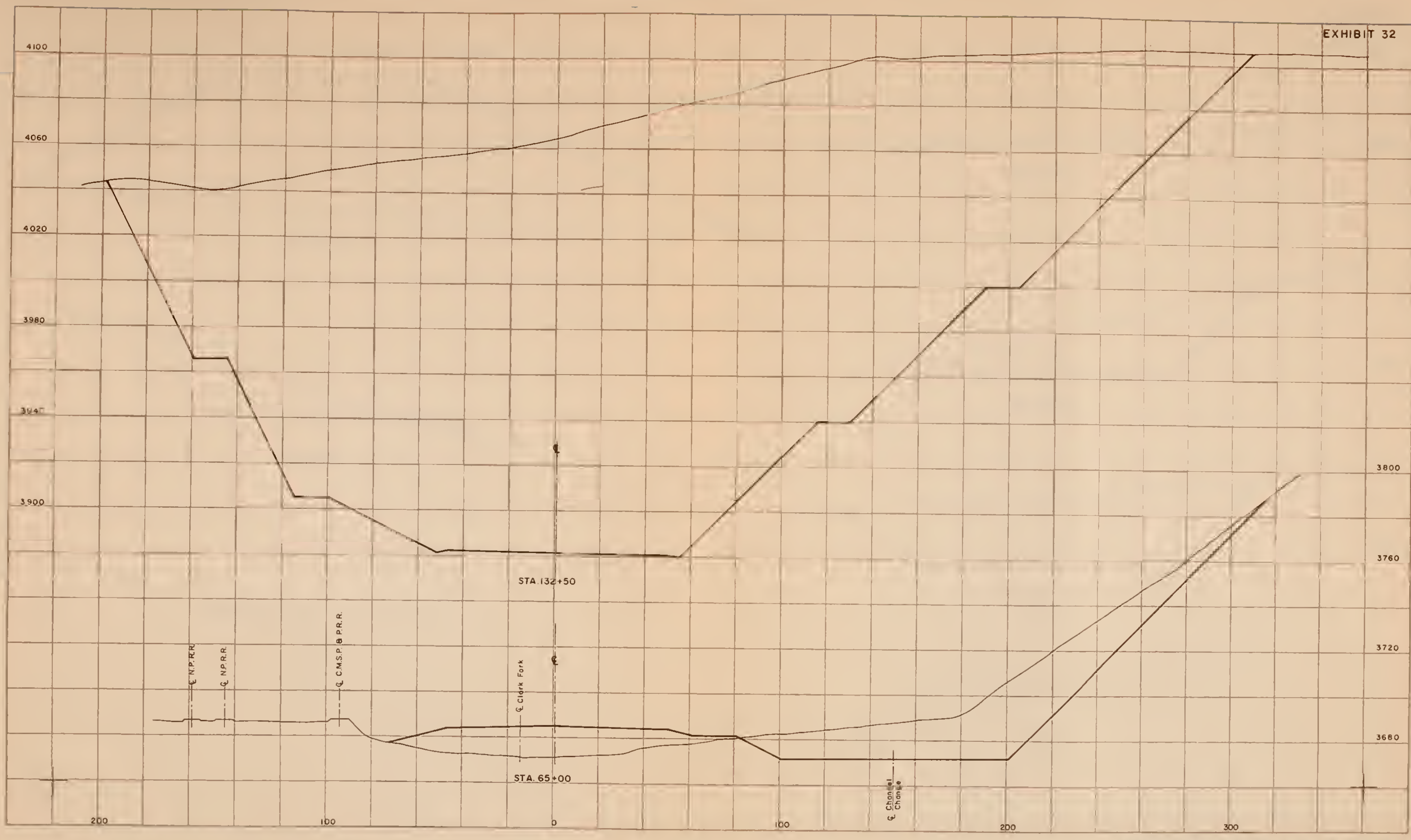

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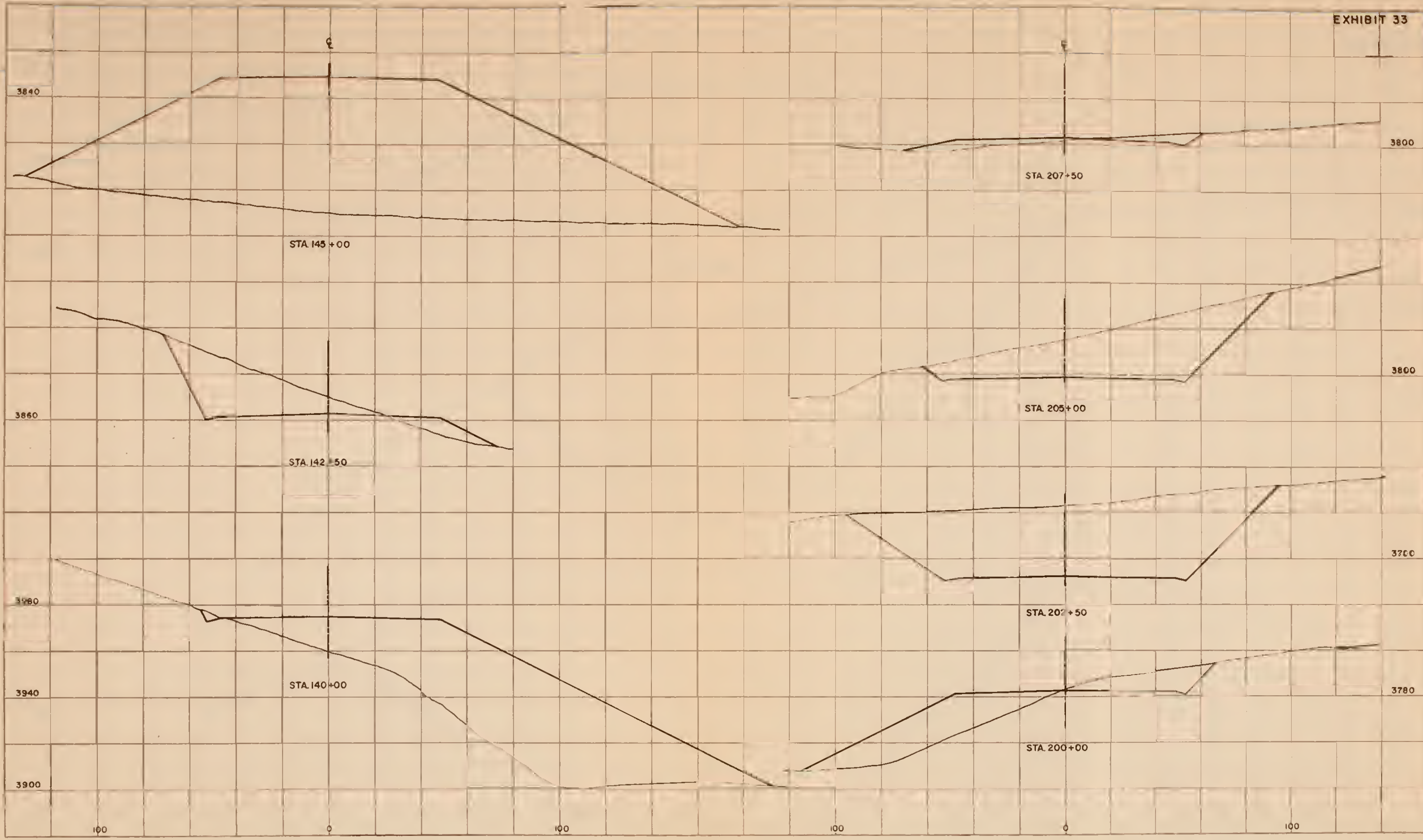

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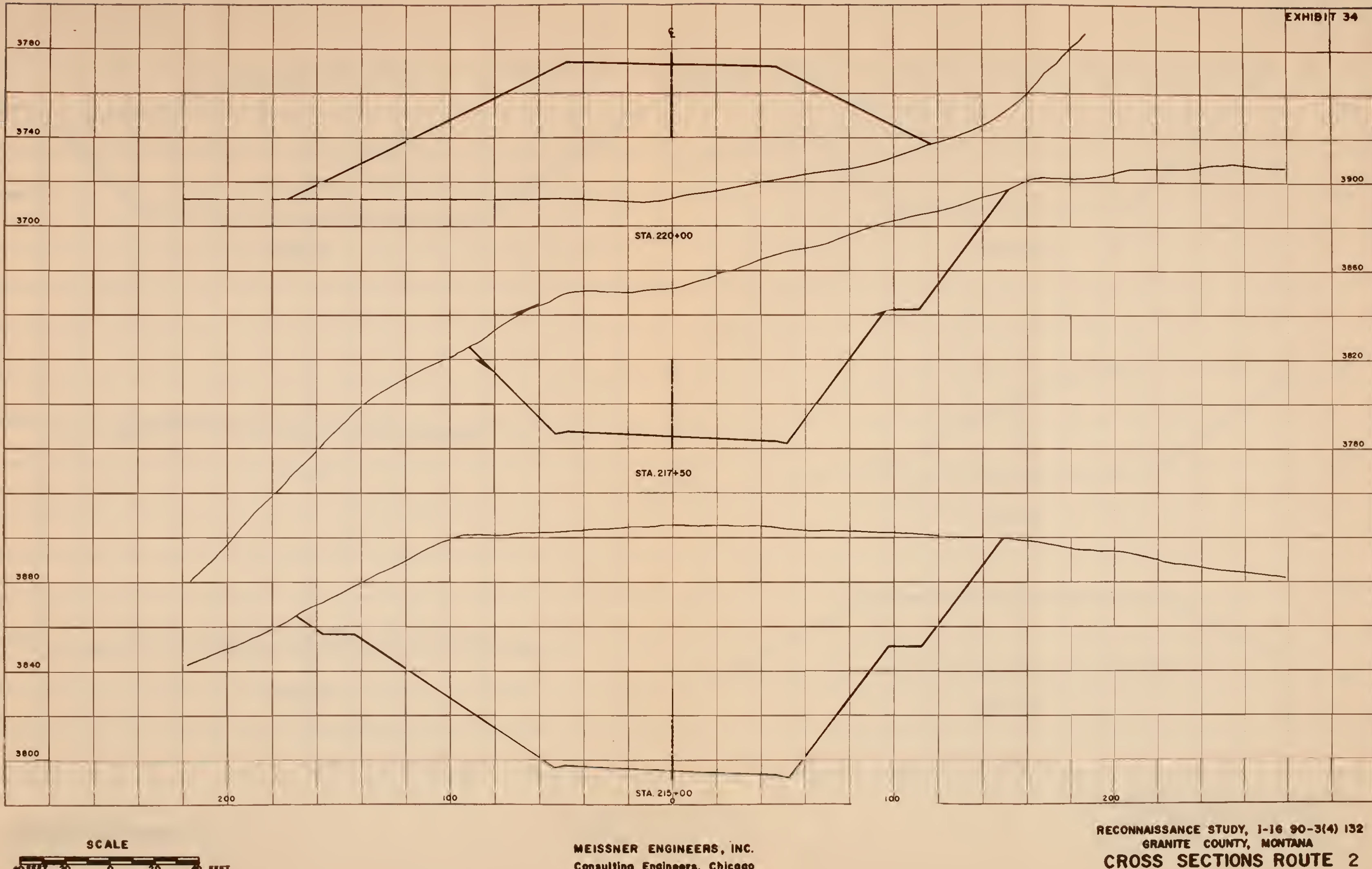

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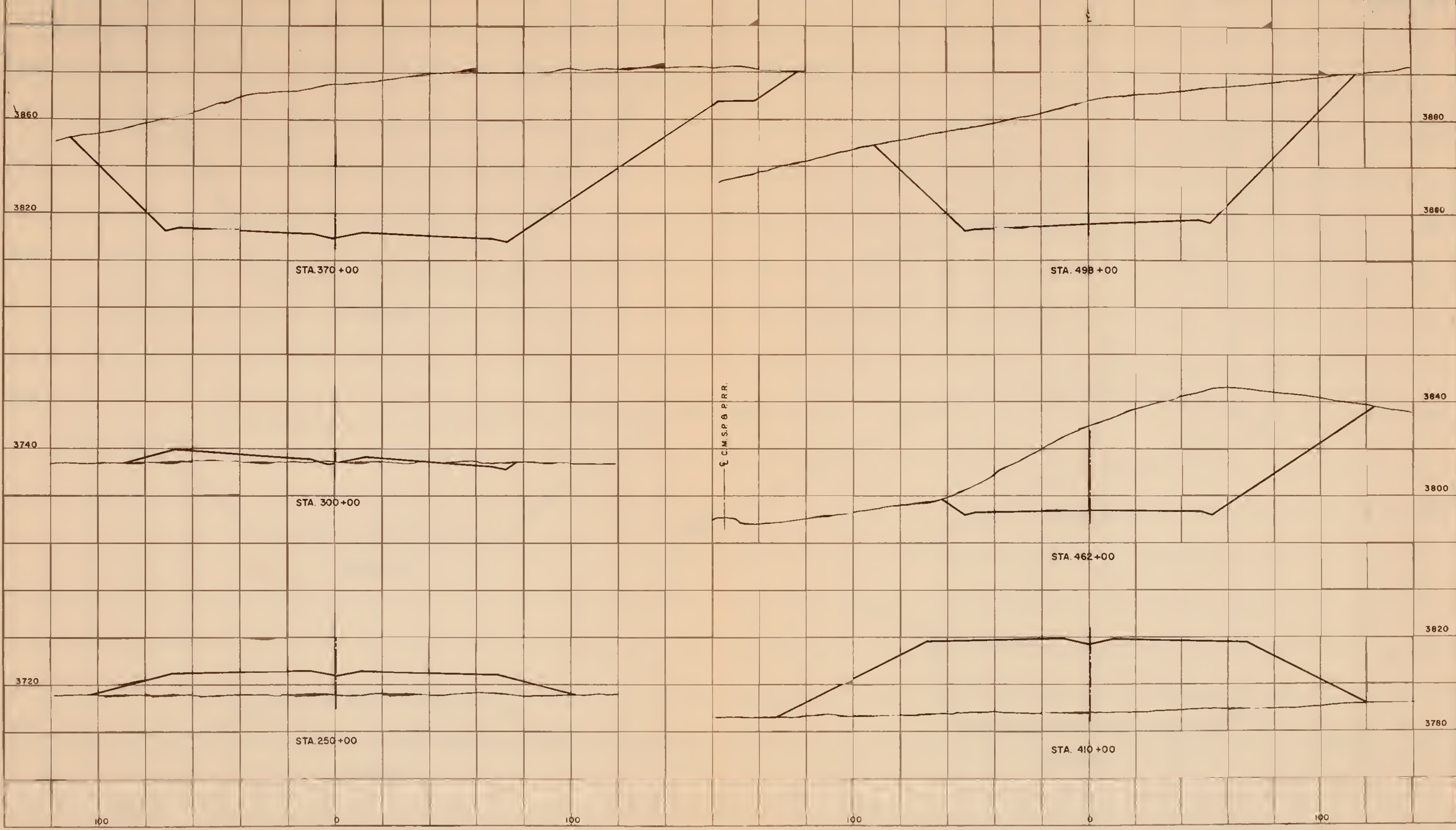

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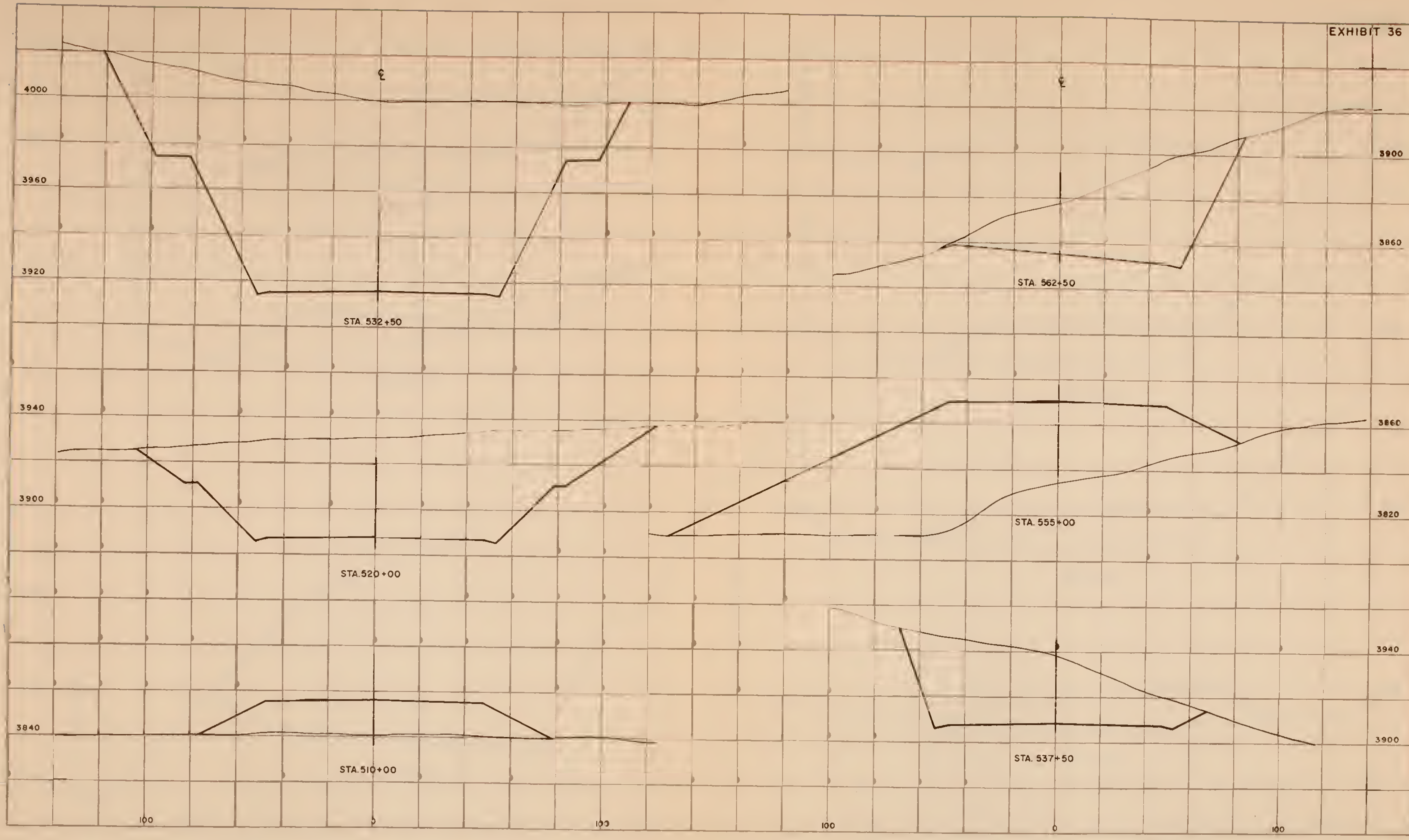

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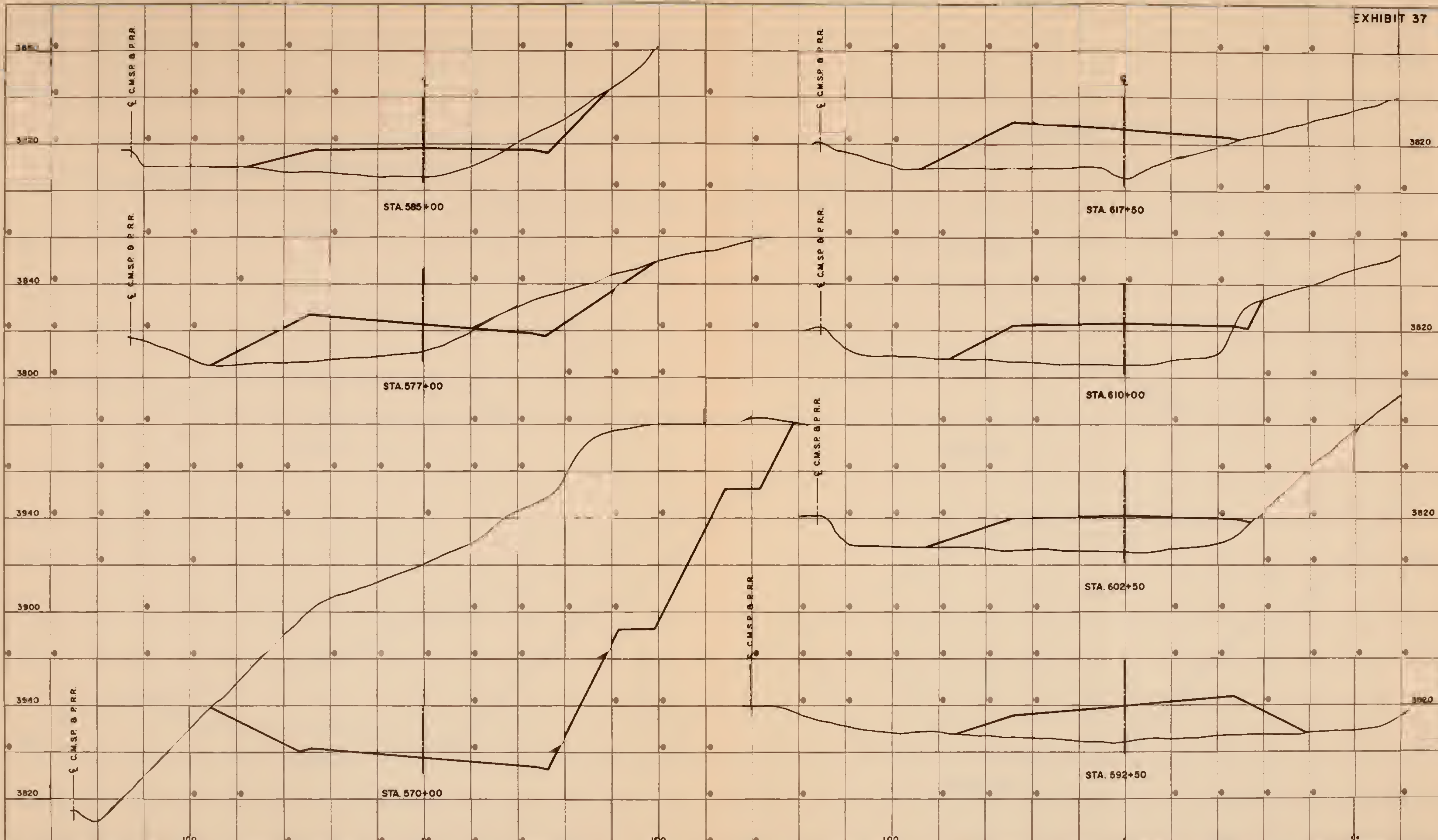

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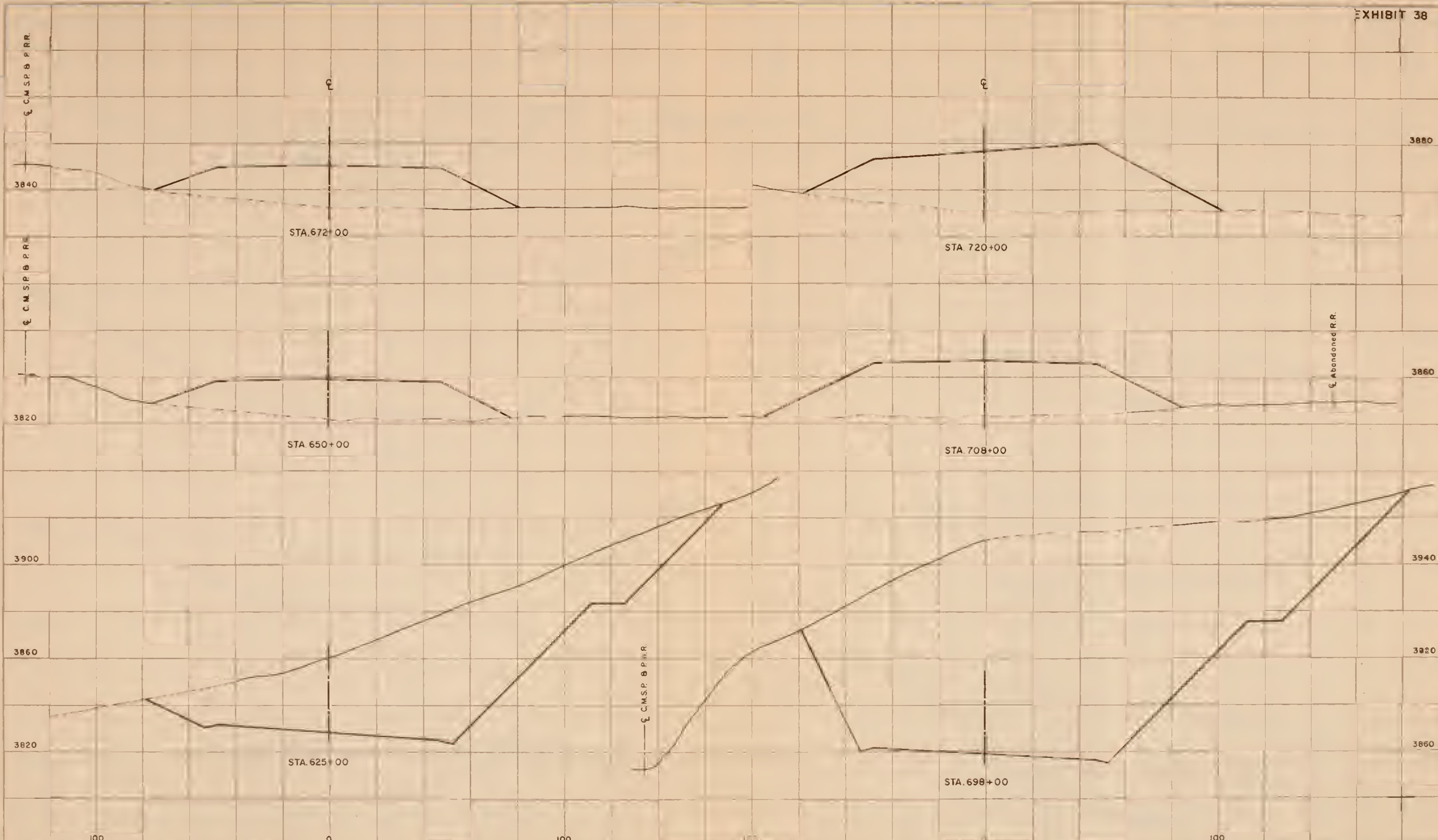

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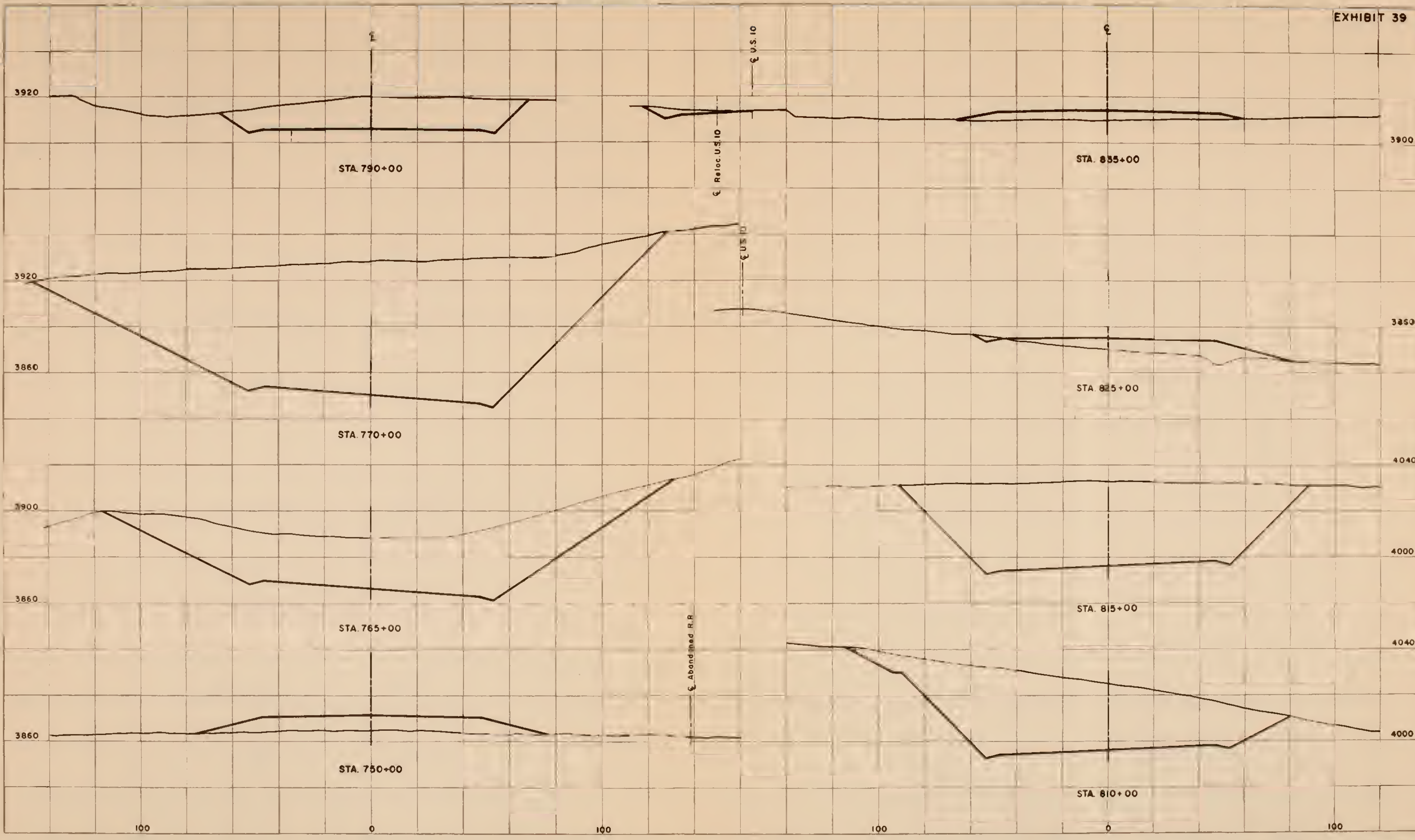

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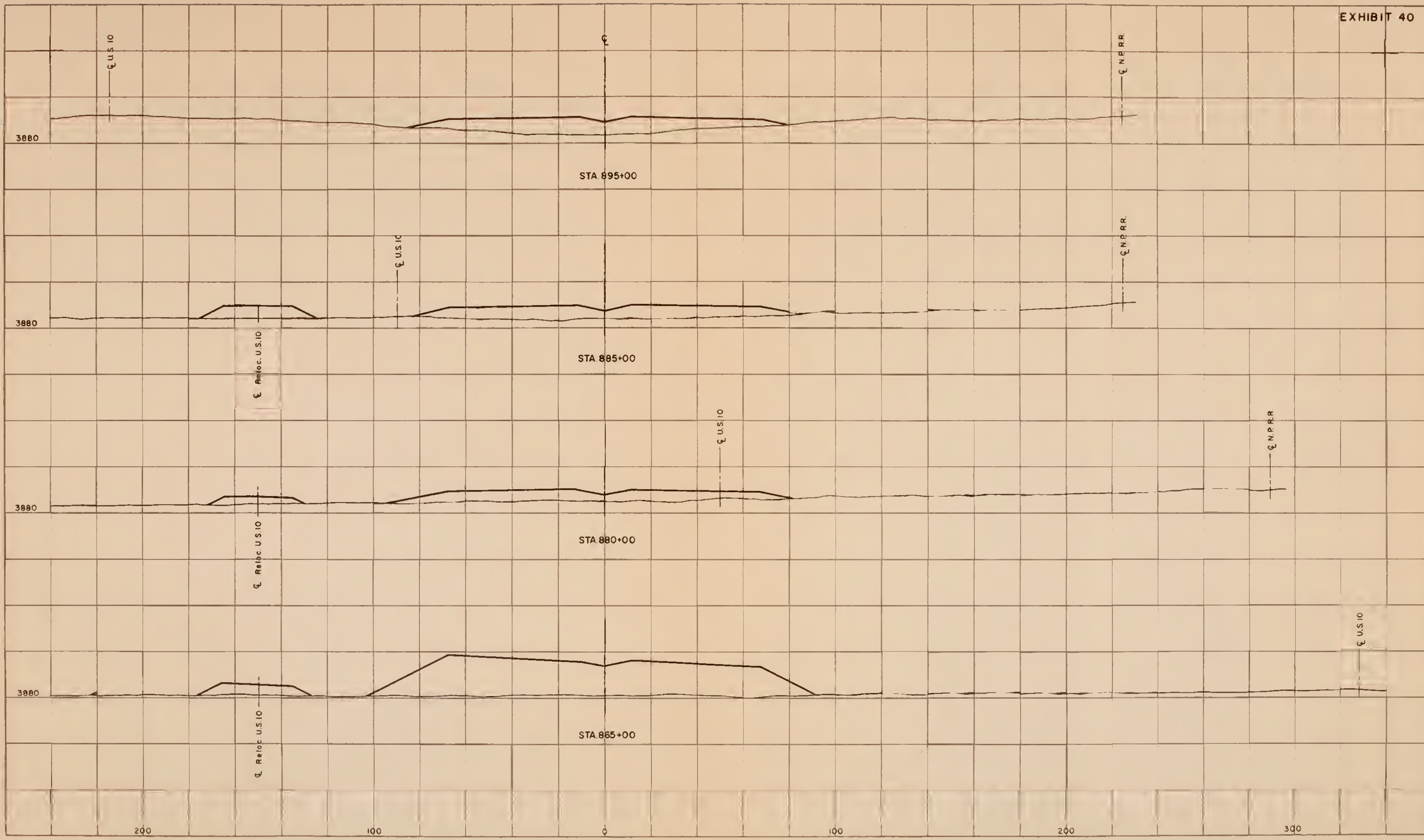

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